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A SYSTEMATIC APPROACH TO AN EXPERIMENTAL ANALYSIS OF YOUNG CHILDREN[1]

SIDNEY W. BIJOU
University of Washington

From time to time someone presents a persuasive appeal for a systematic laboratory approach to child behavior and development (4, 8, 11). It appears that little has been done in initiating programs of this nature. The current situation is such that a re-emphasis of this need and a proposed approach would not be inappropriate.

At present, research in genetic psychology is moving away from an interest in correlating objective descriptions of behavior with age, and toward a search for relevant, antecedent conditions of social behavior. This much-to-be-desired shift is unfortunately being accompanied by the belief that such studies, to be adequate and meaningful, must be made in the natural setting. Furthermore, when the conditions are such that it is impractical to make the required observations, methods may be employed which "estimate" the variables and their relationships. Hence, most approaches involve controlled or uncontrolled field observations, modified clinical techniques, psychometric devices, or some combination of the three. These research procedures will undoubtedly produce information suggestive of pertinent functional relationships. However, it is regrettable that many of those involved in this approach devaluate the contributions that may be made by a systematic laboratory approach.

A case can be made for a systematic laboratory approach if on no other basis than what it has accomplished in other fields of science and in other branches of psychology. It was widely employed during the normative-topographic era that is passing. Perhaps we should repeat many of the "normative laboratory experiments," but this time observe not only the behavior "as it unfolds," but also the independent, manipulatable conditions.

The purpose of this paper is to describe and briefly discuss a promising laboratory method for the systematic study of the behavior of preschool children. A number of considerations influenced the development of the technique. Perhaps they should be made explicit. First, it was believed the method should involve a relatively simple situation, one allowing for considerable control of the experimental variables. Second, it should require the

[1] This research has been supported in part by the Agnes Anderson Foundation.
The author wishes to express his appreciation to Mrs. Deborah Leukel and Mrs. Joanne Tobin for serving as experimenters.

child to make a relatively uncomplicated voluntary response, the frequency of which could be automatically and objectively recorded. Third, it should be adequate to explore problems suggested by laboratory studies with animals as well as those growing out of "field" studies with children.[2] Perhaps the procedures developed do not incorporate to the fullest degree all of these requirements; nevertheless, they have served as excellent guideposts.

The operant or instrumental conditioning situation of the type described by Skinner (13) suggested a promising beginning point. There are a handful of instrumental conditioning studies with children (1, 3, 5, 6, 7, 12, 14), which, though encouraging, are not particularly helpful in establishing a versatile technique. For the most part, the investigators were interested only in demonstrating that selected hypotheses from animal studies hold for young children. Furthermore, these studies, while employing similar learning concepts, were not intended to be systematic in the sense of working out and standardizing the relationships among experimental conditions and procedures. For example, the kinds of reinforcers varied widely. One experimenter used party mints, another chocolate bits, and another plastic balls. No one has yet attempted to determine the relative effectiveness of classes of reinforcers for children at the various developmental stages.

Our preliminary work, therefore, was concerned with evaluating types of reinforcements (appearance of a toy dog, candy, balls, pleasant sounding tones, trinkets, etc.), various kinds of responses (push buttons and lights, peg boards and lights, pump handles, dropping a ball in a hole, etc.), and ways of setting up experimental procedures. From these efforts emerged the apparatus and the procedures described below.

Apparatus[3]

The apparatus, shown schematically in Figures 1 and 2, is the core of a standard experimental situation. Like most operant conditioning devices, it consists of three parts—a response mechanism, a reinforcer dispenser, and a recording device.

To make a response, the child simply takes a ball from a receptacle and drops it into a hole. The ball, a Spaulding handball, is always presented in the lower tube, and the situation is such that it can be dropped only into

[2] Relationships based on animal studies need to be tested with human subjects before reasonable generalizations may be made; likewise, relationships suggested by field studies with children require evaluation under laboratory conditions to permit greater control of the relevant antecedent variables.

[3] The apparatus was constructed in the Psychology Department Shop by Mr. George E. Price. The author wishes to express his appreciation to Mr. Price for his many valuable and ingenious suggestions.

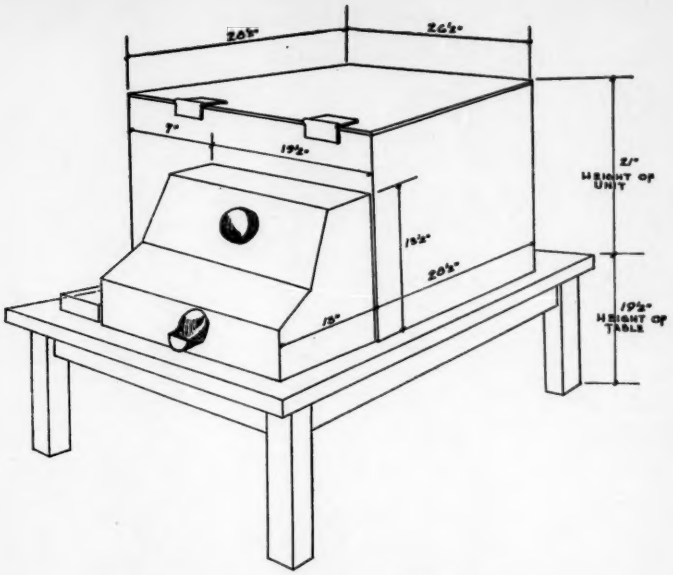

FIGURE 1—Exterior view of the apparatus.

the upper hole. Findings from exploratory investigations indicated that this type of response would be practical with children. The task was simple and so obvious that the child could almost instruct himself. The device also provided for control over the frequency of responding, since a response could not be made until the ball appeared. The appearance of the ball thus served as a discriminative stimulus. Finally, such a mode of responding could readily be adopted to study a variety of problems, (*a*) by merely varying the number of receiving holes, and (*b*) by changing the time between presentations of the ball. The former can be accomplished by interchanging the panel with one hole, as shown in the diagram, with others containing two or more receiving holes; the latter by adjusting the timing mechanism which detains the ball inside of the box. Thus with two modifications in the response mechanism the apparatus may be adapted for problems of learning, discrimination, response maintenance, and problem solving. It should be emphasized that we have developed a controlled operant rather than a free operant situation.

The device controlling time between trials also starts and stops the machine which delivers reinforcers. Essentially the dispenser is a motor-driven bicycle-type chain on which are attached hooks five-eighths of an

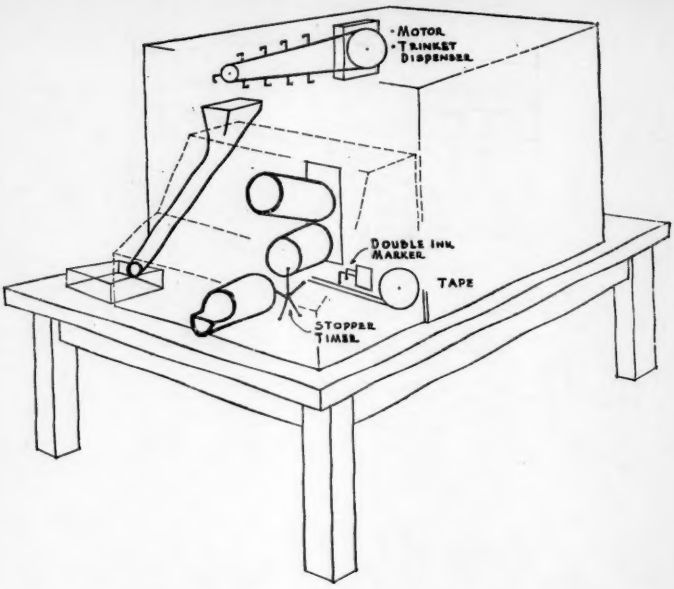

FIGURE 2—Cutaway view of the apparatus showing the timing device, dispenser, and marker system.

inch apart. "Loading" consists of hanging plastic trinkets[4] on the hooks. Each time the ball strikes the delaying mechanism the chain is moved forward one unit, and the trinket on the hook under the front bearing falls into the chute below. The final destination of the incentive is a covered, clear plastic box placed at the front edge of the table to the left of the child. The delivery of a trinket is accompanied by two distinct auditory stimuli—a brief hum of the motor, and the sound of the trinket sliding down the metal chute and striking the side of the receiving box.

The type of dispenser employed proved to be eminently suitable for studying reinforcement and extinction under a diversity of conditions. For instance, by using two dispensers in series it is possible to set up an almost infinite number of intermittent schedules. It is also possible to study the amount of reinforcement per trial by varying the number of trinkets delivered, and the quality of reinforcement by using candy or other edibles in place of trinkets.

[4] Trinkets are obtained from the Viking Company, 530 Golden Gate Avenue, San Francisco 2, California.

A word about the trinkets: Nowlis and Nowlis (8) have stated that the multi-color and form plastic trinkets (the kind seen in the omnipresent gum-ball machines) serve admirably as reinforcers for preschool children. Our experience confirms this. These "toys" or "charms" have an almost universal appeal for boys and girls between the ages of two and seven, and when "mixtures" are used interest remains high during an experiment and between experimental periods. They have the additional obvious advantage of avoiding problems associated with edible incentives. The use of these trinkets as they relate to age, sex, socio-economic status, and to other types of incentives, comprises a block of studies that needs to be worked out.

Responses are recorded on a polygraph. Paper tape, three-eighths of an inch wide, moves under two ink-writing pens at the rate of one millimeter per second. One marker indicates the number of responses and intervals between responses; the other records the reinforcements. A switch controlling the polygraph motor is on a 15-foot extension cord so as to be readily available to the experimenter.

Experimental Procedure

As in experimental work with animals (2), it is highly desirable, and even necessary, to have a standard preparation procedure for child subjects. This preparation serves to reduce the influence of emotional reaction to a new situation on the behavior to be observed, and to minimize marked differences in rapport that may be established between the child and the experimenter. (Further systematic, objective evidence on this interrelationship would be of tremendous value.) Preliminary operations consist of the experimenter's becoming acquainted with all children in the nursery school, "playing" with the subject immediately preceding the experimental "run," and orienting the child to the experimental task and conditions prior to allowing the first response.

In preparing for a study, the experimenter, a young woman, first makes herself known to the children by watching them at play in the yard and in the school rooms. Soon she is regarded as a member of the staff or as a teacher in training. When a child is selected to be a subject, the experimenter approaches him and invites him to come and "play with some toys." On entering the laboratory (Figure 3), she suggests that the child sit at a table upon which are a plastic dog and a tin dog house.[5] After a few introductory remarks, the experimenter puts the dog in the house and shows the child that tapping on the table will make the dog shoot out. She next demonstrates that the dog will also pop out if called by his name, "Sparky." The subject is then encouraged "to make the dog come

[5] The toy is made by Byron Products, Western Distributors, Pacific Trading Company, Los Angeles, California.

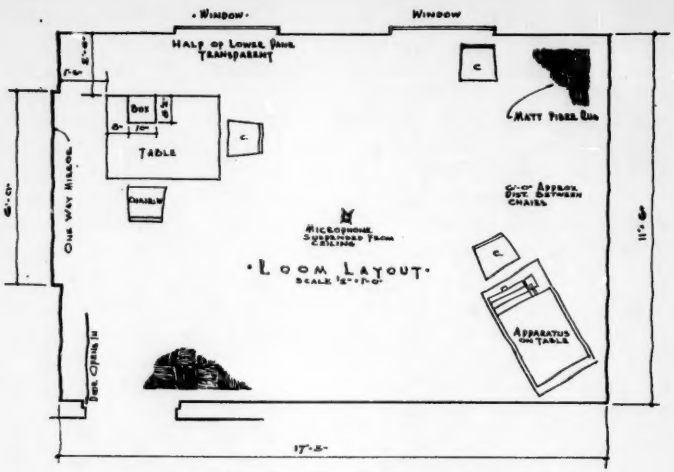

FIGURE 3—Layout of the experimental room.

out." Once the child takes charge of the toy, play is permitted until he has made the dog come out at least four times. A delay of 15 seconds or more between insertion and pop-out is the criterion for termination of warm-up activity.

The next step consists of inviting the subject to the table with the apparatus. After he is settled in the juvenile chair in front of the apparatus, a plywood screen is removed and the experimenter proceeds with the orientation and instructions. She shows a handful of trinkets and says: "You can get some of these to keep, to take home with you." She hands the child the ball and says: "When you put the ball in there (pointing to the upper opening) some of these toys will come down here (pointing to the covered plastic box. The ball will come out here again. You can put it back into the top hole as many times as you like. We will leave all the toys that come down in the box until we are finished, and are ready to go." The experimenter takes a seat six feet to the rear of the subject and offers no further suggestions or instructions.

Comments and questions addressed to her are reacted to in a pleasant non-directive fashion, e.g., "You think the thing is broken." "You think no more will come out." When the experiment has been completed the receiving box is opened, the trinkets are given to the child, and the child is returned to his group.

Required variations in manipulatable conditions during an experiment, such as running extinction trials without the sound of the motor hum, are

accomplished by flipping silently operating switches on a small control panel concealed under the experimenter's chair.

In addition to measures of frequency of responding, a second measure of behavior has been attempted (9, 10). To record emotional behavior, an observer behind a one-way screen made judgments every 10 seconds, describing activity level. Each judgment is subdivided into verbal-motor components and direction of behavior.

To date, two groups of studies have been conducted. The first series has been designed to explicate some of the aspects of the situation, e.g., the reinforcing value of putting the ball in the hole, the relationship of age and sex to performance and extinction, and the effects of different lengths of extinction periods. The other group of studies has been concerned with exploring some functional relationships suggested by animal experiments, e.g., the relationships between number of responses and resistance to extinction; and the effect of a secondary reinforcing stimulus on extinction.

Summary

It is believed that a systematic laboratory approach can offer significant contributions to a scientific analysis of child behavior and development. On the basis of this conviction, a laboratory methodology has been developed involving a simple manual operant, trinkets for reinforcers, and a device for recording response frequencies. The experimental procedures are such that findings and "hunches" from experiments with animals and studies with human subjects may be evaluated in a laboratory setting. Although systematic exploration could profitably begin with any of a number of interesting problems, the present program is concerned with acquired drives since most of the current viewpoints on child behavior and development rest heavily on this concept. Initial efforts have been devoted to analyzing the consequences of different schedules of reinforcement and the influence of two auditory stimuli accompanying reinforcement during training.

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FORMS OF MENTAL GROWTH PATTERNS REVEALED BY REANALYSIS OF THE HARVARD GROWTH DATA[1]

ETHEL L. CORNELL and CHARLES M. ARMSTRONG
Research Division, New York State Education Department

This report deals with a study which began as a supplementary and minor effort to check certain hypotheses about mental growth by a reanalysis of a few hundred cases whose growth records were recorded in one volume of the Harvard Growth Study (2). The findings from the first sample of 250 cases became so intriguing that the study was extended until it included over 1100 of the 1500 cases recorded in this volume.

The hypothesis we wished to check was that there may be a limited number of patterns of mental growth which will suffice to characterize the mental growth of most individuals. If these can be identified by graphic methods of plotting longitudinal data for individuals without using elaborate statistical techniques, it might be possible for schools to utilize such methods with great advantage to discover the developmental needs of children and adolescents.

The findings have raised many questions which seem to the authors of profound importance for education, especially at the early adolescent stage. This paper will report the development of the method of analysis, the major results of the application of this method to the Harvard growth data, and some of the possible implications for education. It is believed that these are of sufficient importance to warrant a major longitudinal study involving a wide scope of interrelationships.

DEVELOPMENT OF METHOD

From the various substudies of the Harvard study, and from other studies of growth, it seemed that perhaps the most promising lead was

[1] The research reported in this article was carried on in the Division of Research of the New York State Education Department under the direction of Dr. Warren W. Coxe.

toward a method of plotting growth in terms of "per cent of maturity." Before "per cent of maturity" at each age could be determinied, however, various preliminary steps were necessary.

1. The first step in the development of the method was to plot mental age (in months) at each chronological age on semi-log paper. The Harvard growth data reported the mental ages from two group intelligence tests given in close succession each year for 12 consecutive years for about 1500

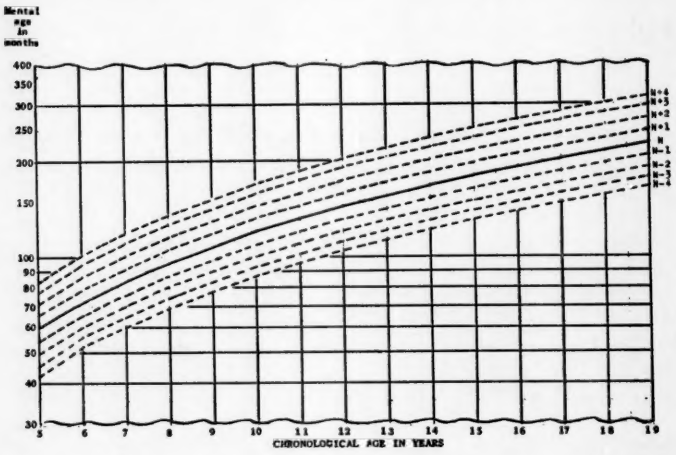

FIGURE 1—The "N-curve." Theoretical Expectancy of Mental Growth at IQ = 100 (Mental Age Equal to Chronological Age), Plotted on Semi-log Paper.

individuals. After some experimentation, it was decided to use the average of the two tests for an individual as his mental age for each year. Preliminary work with about 250 cases indicated that the trend of growth of an individual was more clearly apparent on this type of graph than on the usual arithmetic paper.

If equivalent mental and chronological ages are plotted on semi-log paper, the result is a smooth curve with increments decreasing in vertical distance from the base, as shown in Figure 1. This curve, based on the usual assumption of "normal" growth, we called the "N-curve." In the first series of cases plotted, it was discovered that by moving this "N-curve" (the theoretical "normal" curve) up or down vertically on the semi-log paper, a position could be discovered which approximately fitted the general trend of development for most of the individuals. This N-curve was fitted to the individual plots by moving the curve up or down by convenient

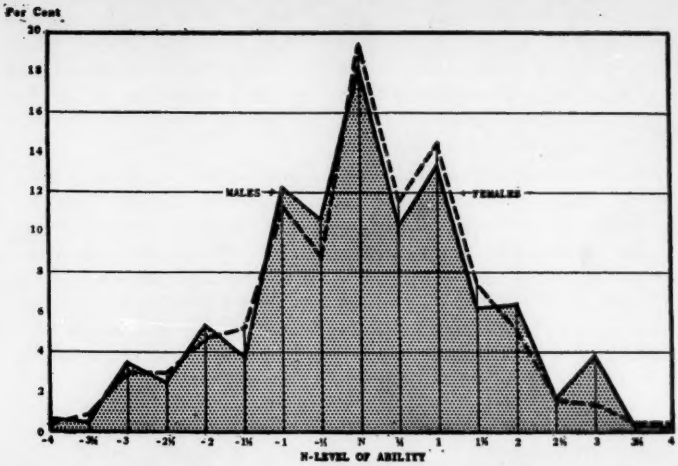

FIGURE 2—Percentage Distribution of Estimated Ability in Terms of N-level, Based on Individuals' Curves of Mental Age Plotted Over Period of Ages 6 to 18.

steps of the semi-log scale.[2] The level at which the best fit was secured was described as N, N + ½, N + 1, N − ½, N − 1, etc., expressed in scale units of the chart. The general level of each individual's ability during the years from about 6 to 18 was determined in this way and expressed as the "N-level," that is, the number of scale steps above or below N at which his curve of best fit was drawn.

The curve drawn at the N position would, of course, represent growth at a constant IQ of 100, since the mental age is equal to the chronological age at each point. A parallel curve at a higher or lower level would also indicate a constant IQ, since, on a semi-log scale, it would represent proportional increments. This analysis therefore does not change the concept of the IQ: it merely makes the theoretical expectation easier to visualize than the usual plot of mental and chronological age on arithmetic paper. The IQ levels indicated by the deviations from N on the semi-log scale are as follows:

N − 4 = IQ 72	N + 1 = IQ 109
N − 3 = IQ 77	N + 2 = IQ 120
N − 2 = IQ 83	N + 3 = IQ 132
N − 1 = IQ 91	N + 4 = IQ 140

[2] The procedure used was to fit a transparent mask with its edge cut to conform to the N-curve over each plot and to draw the curve on the plot at its best-fitting position.

The total distribution of "N-level of ability" for 434 males and 296 females, which describes the total status of the individual over the whole elementary and secondary school period, is very similar to the distribution of IQs at any given age, as shown in Figure 2, and indicates that the use of N-level as a longitudinal measure of ability has an interpretation roughly equivalent to the usual interpretation of IQ.

2. The second step in developing the method was to determine a reasonable "maturity value" or adult limit of growth in mental age for each individual. Early clinical evidence led to the assumption that the average mental age of adults is about the same as the average mental age of unselected 14-year-olds or 15-year-olds. On the other hand, recent investigations suggest that mental *growth* continues at least into the early twenties. Examination of the individual N-level curves from the Harvard data indicated that most individuals showed continued growth in mental age after 15. The point selected to represent the maturity value for the individual, which seemed best justified empirically, was the point at which the individual's N-level curve intersected the chronological-age base line at age 18. While this gives a higher average adult mental age than is usually assumed, and a higher mental age than many individuals had reached by the end of the record, it did not appear unreasonable as the level that would be reached if mental growth continued to age 20 or 21. On this hypothesis, an individual whose N-level curve was at the N ("normal") position would have an assumed maturity-value of a mental age of 18 years; an individual whose curve was at the N + 1 level would have an assumed maturity-value of a mental age of 20 years; an individual at the N — 1 level would have an assumed maturity-value of a mental age of 16 years 8 months.[8]

3. The third step in the development of the method required the conversion of mental ages into units of mental development which would be more nearly equivalent than mental age units at different levels of development. The problem of devising a scale of mental development with equal units has been one of the most difficult problems dealt with by test makers and test statisticians for many years. Under the direction of Dearborn, H. H. Long had applied to the Harvard growth data the technique developed by Thurstone to secure a scale of "absolute" units. We modified

[8] It is difficult to check the validity of these assumptions because not all individuals in the Harvard study were carried into the 18th year. Those who were had a lower median mental age at every age than those whose records ended at 16 or 17 years of age, presumably because the latter groups were graduated from high school at an earlier age. The group of males whose records ended at 17 had median mental ages closest to chronological age at all ages. At age 17 (assumed median age 17-6), this group had a median mental age of 17-4. But the group whose records ended at 18 years had a median mental age, at 17-6, of 16-4 and at 18-6 of 16-9, while the group whose records ended at 16 were comparatively accelerated over the entire period and had a median mental age, at 16-6, of 17-1. Females showed the same relationships, with medians slightly higher.

Long's values in certain ways, described elsewhere (1), and developed a scale, based on Long's work, with equal units which we designated as "cma units."[4] When mental ages are converted into cma units, we have data which hypothetically afford a basis for determining the percentage of development toward the individual's maturity value from age six or seven on.

4. The fourth step was the plotting on probability paper of percentage of development at each age for each individual. On probability paper, the scale is such that the cumulative percentages of a normal probability distribution will fall on a straight line. This form of distribution is as reasonable an assumption as any other to describe the mode of growth of biological organisms in general.

The total number of cases from the Harvard data whose records we worked with in one way or another was 610 males, 504 females. Not all of these cases had the basic plots of mental age made on semi-log paper: some individuals of the North European ethnic group were omitted because the number of North Europeans was so greatly in excess of other groups. Of those whose mental ages were plotted, 67 were not classifiable on a single N-level and were excluded for special consideration later. This reduced the number of cases to 491 males and 453 females. Of this number, 56 males and 95 females had records which were too incomplete to justify inclusion, leaving 435 males and 358 females with the necessary data as to ethnic origin, socio-economic status[5] and general N-level of ability, who could be classified into subgroups according to sex, ethnic origin, and socio-economic status, and whose patterns of mental development within subgroups could be studied.

Results

Forms of Mental Growth Pattern Identified

When the general N-level of ability was determined for each individual and his probable maturity level converted to its value in terms of cma units, and when his mental age at each year was converted to its corresponding cma value and the percentage of maturity at each age calculated and plotted on probability paper, the individual graphs were examined to discover whether they could be classified into distinctive patterns of mental growth

[4] This designation, for office convenience, utilized the initials of Charles M. Armstrong, who was responsible for the statistics. Since the letters stand equally well for "converted mental age," the designation is retained. The table of cma units is appended to this paper.

[5] The Harvard data included a five-point classification by father's occupational level, when available. Higher levels (I and II) comprised professional, semi-professional, managerial and large business; middle level (III), skilled and clerical; lower levels (IV and V), semi-skilled and unskilled occupations.

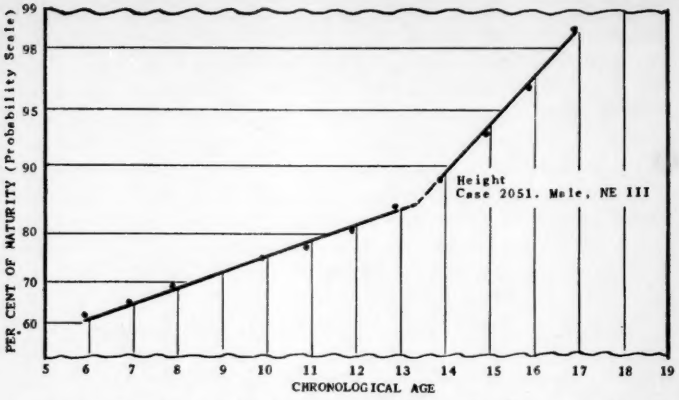

FIGURE 3—Growth in Height of an Individual, Plotted as Per Cent of Maturity on Probability Scale. Typical Form.

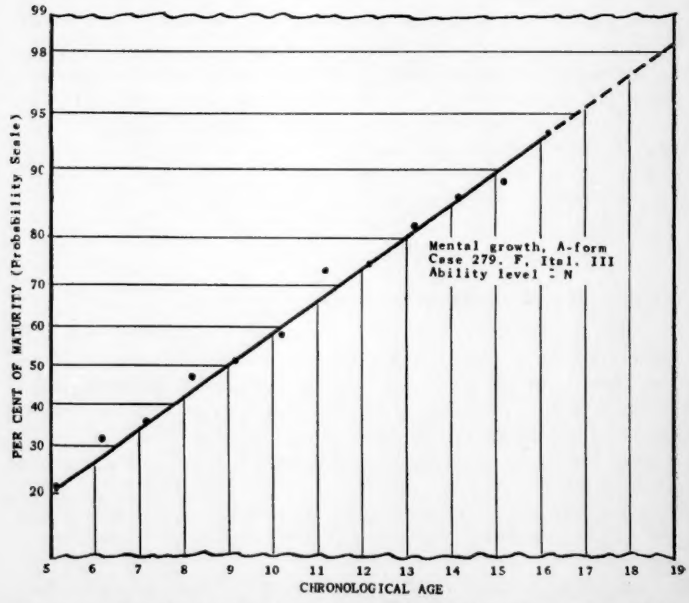

FIGURE 4—Mental Growth of an Individual Plotted as Per Cent of Maturity on Probability Scale. A-form of Mental Growth Pattern.

or whether the uniqueness of individual growth made such classification impossible.

As a check on the hypothesis that a consistent growth pattern might be identified as a straight line on probablity paper, we had also plotted growth in height as percentage of maturity. There was clearly one typical growth pattern in height, illustrated in Figure 3. This consisted of a straight line between the ages of six or seven, usually, up to a point varying for different individuals from about age 11 to age 14 or 15, followed by another straight line at a steeper slope toward maturity. There were variations in the slope of the earlier line, in the age at which the break between the two lines occurred (corresponding to differences in the age of puberty), and in the steepness of the second line, but a pattern of this form was the general pattern and variations from it appeared to be specific and individual.

In contrast to the pattern for height, no single pattern of mental growth was found, but four general patterns were identified, with some subclassifications. The forms of mental growth pattern used as a basis for classifica-

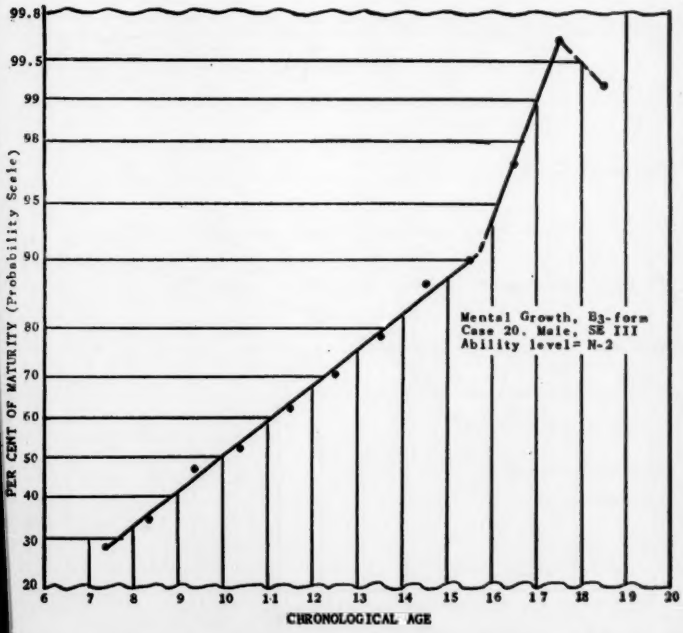

FIGURE 5—Mental Growth Plotted as Per Cent of Maturity. B_3-form of Mental Growth Pattern.

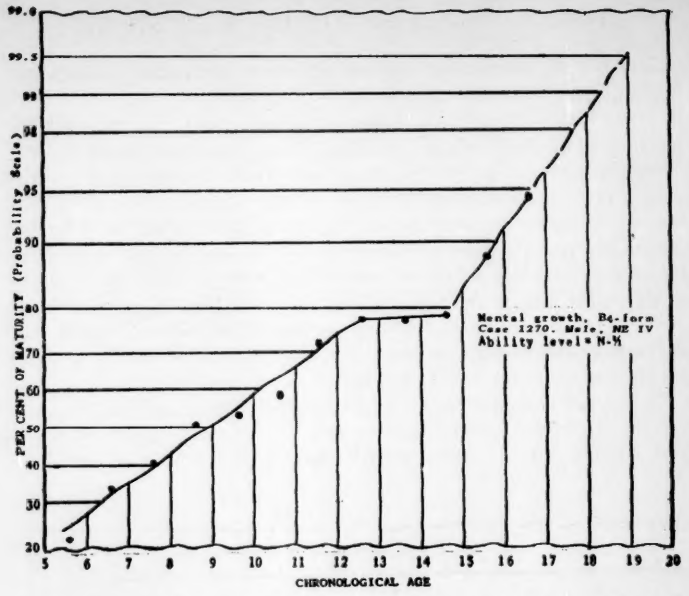

FIGURE 6—Mental Growth Plotted as Per Cent of Maturity. B_4-form of Mental Growth Pattern.

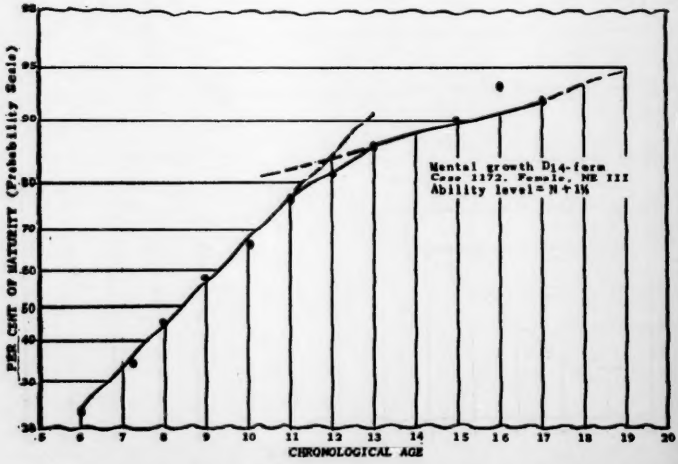

FIGURE 7—Mental Growth Plotted as Per Cent of Maturity. D_{14}-form of Mental Growth Pattern.

tion, after many tentative groupings and regroupings, may be described as follows:

A—Those which could be reasonably well defined by a single straight line from age 6 or 7 to 18. This is the form that would be derived from a systematic single growth curve with an initial period of accelerating rate (i.e., increasing increments per unit of time), a maximum rate reached at the mid-point of the curve, and a later period of decelerating rate by increments equivalent to, but in the reverse direction from, those of the accelerating phase. This pattern we designated as the A-form (Fig. 4).

B—Those which could be reasonably well defined by two straight lines, breaking somewhere in the adolescent ages, with the slope of the later line steeper than that of the earlier line. This would be the form derived from two distinct growth curves, which could be interpreted as two cycles of growth. There were two major variants of the pattern designated as the B-form:

B_3—Those in which the end of the first line coincided with the beginning of the second line (Fig. 5).

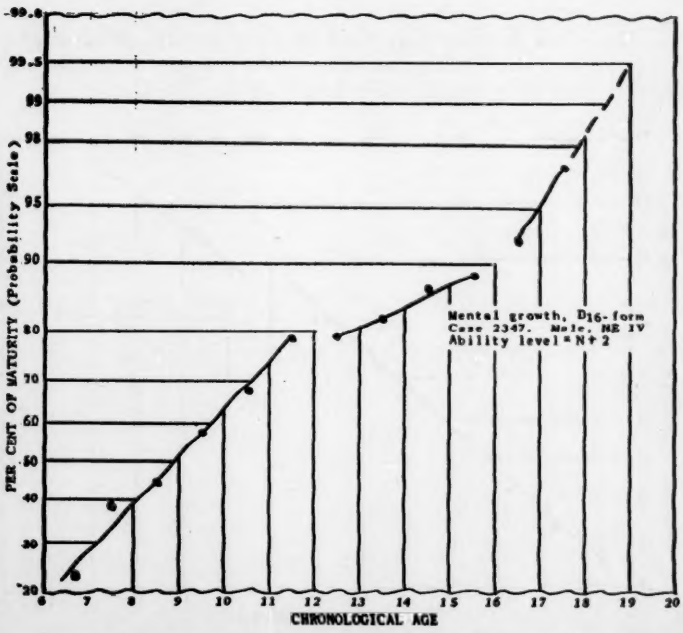

FIGURE 8—*Mental Growth Plotted as Per Cent of Maturity.* D_{16}*-form of* Mental Growth Pattern.

B_4—Those in which there was a break between the end of the first line and the beginning of the second line, marking a "flat" period, which had previously been noted as characteristic of many of the N-curves (Fig. 6).

These curves would indicate that there were two growth curves (or cycles) which might or might not be well synchronized. The steeper slope of the later line suggests fairly rapid approach to mental maturity after the adolescent change.

D—Those which could be reasonably well defined by two straight lines breaking somewhere in adolescence but with the slope of the later line less steep than that of the earlier line. Three variants of the pattern designated as the D-form were identified:

D_{14}—Those in which the slope of the second line was very much less than that of the first and defined the whole course of the second line (Fig. 7).

D_{16}—Those in which the relationships of the lines were similar to D_{14}, but a sharp upturn was suggested by one or two of the last measures (at ages 16, 17, or 18) (Fig. 8).

D_{22}—Those in which there was a flat period in early adolescence, followed by a definite rise in the slope, not so steep as the first line, but steeper than the slope defined as D_{14} or D_{16} (Fig. 9).

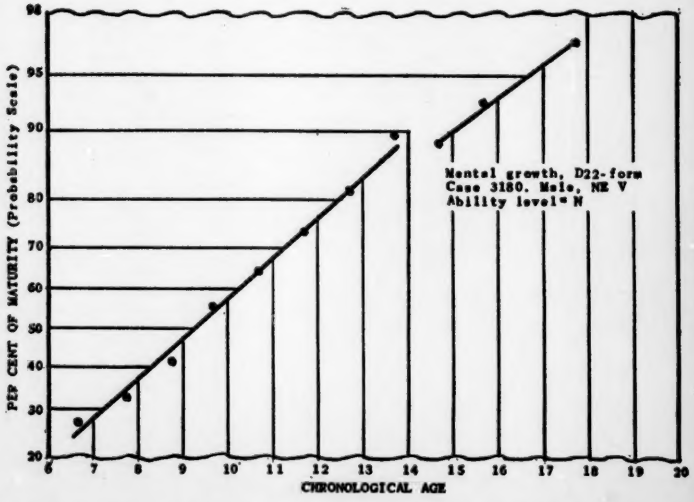

FIGURE 9—Mental Growth Plotted as Per Cent of Maturity. D_{22}-form of Mental Growth Pattern.

These patterns, like the B-forms, suggest that there are two cycles of growth, but differ from the B-form in that the childhood cycle is relatively more rapid (in terms of maturation) than the development following the adolescent change.

S—Those in which growth tended to be step-wise, that is, in spurts followed by pauses. General tendencies of an A-, B- or D-form were identifiable, but the pattern was not definable by straight lines. These patterns were designated as S-forms.

Distribution of Forms of Mental Growth Pattern

1. The incidence of different forms of mental growth patterns for the total sample is shown in Table 1. More of the female records were incomplete, largely because more Italian females than males did not have records going beyond age 15 in the original Harvard data.

There are some possible differences between males and females in the forms of growth patterns. Females appear to have a larger proportion in the A-pattern and smaller proportions in the D- and S-patterns. Only in the A-pattern is the difference more than three times its sigma.

2. The different forms of mental growth pattern appear to be possibly differently distributed in the different ethnic groups, but when these are subdivided according to socio-economic classification, the subgroups become rather too small for conclusive evidence. Since the socio-economic classes are not comparably distributed among the different ethnic groups, the differences found are only suggestive (Tables 2 and 3).

TABLE 1

FORMS OF MENTAL GROWTH PATTERN IN TOTAL GROUP

Mental Growth Pattern	*No. of Cases*		*Per Cent of Total*		*Per Cent of Classified*	
	M	F	M	F	M	F
A-form	44	79	9.0	17.4	10.1*	22.1*
B-form	120	109	24.4	24.1	27.6	30.4
D-form	140	88	28.5	19.4	32.2†	24.6†
S-form	131	82	26.7	18.1	30.1‡	22.9‡
Total classified	435	358	88.6	79.0	100.0	100.0
Incomplete	56	95	11.4§	21.0§		
Total	491	453	100.0	100.0		

* Diff = 12.0; σ_{diff} = 2.6.
† Diff = 7.6; σ_{diff} = 3.2.
‡ Diff = 7.2; σ_{diff} = 3.1.
§ Diff = 9.6; σ_{diff} = 2.4.

TABLE 2

PERCENTAGE DISTRIBUTION OF FORMS OF MENTAL GROWTH PATTERN AMONG DIFFERENT ETHNIC GROUPS
(Basis: Number Classified))

Mental Growth Pattern	MALES				FEMALES			
	No. Eur.	*Ital.*	*So. Eur.*	*Jewish*	*No. Eur.*	*Ital.*	*So. Eur.*	*Jewish*
A-form	8.6	13.0	13.3	12.1	24.9	21.9	0	18.6
B-form	28.6	28.3	16.7	27.3	27.4	35.2	35.3	30.2
D-form	37.5*	16.3*	33.3	30.3	35.2†	7.6†	11.8	23.3
S-form	25.3‡	42.4‡	36.7	30.3	12.4§	35.2§	52.9	27.9
	100.0	100.0	100.0	100.0	99.9	99.9	100.0	100.0
No. classified	280	92	30	33	193	105	17	43
Incomplete	37	12	4	3	35	52	2	6
Total cases	317	104	34	36	228	157	19	49

* Diff = 21.2; $\sigma_{diff} = 4.7$.
† Diff = 27.6; $\sigma_{diff} = 4.4$.
‡ Diff = 17.1; $\sigma_{diff} = 6.1$.
§ Diff = 22.8; $\sigma_{diff} = 5.2$.

TABLE 3

PERCENTAGE DISTRIBUTION OF FORMS OF MENTAL GROWTH PATTERN AMONG NORTH EUROPEANS AND ITALIANS IN SOCIO-ECONOMIC CLASSES IV-V

Mental Growth Pattern	MALES—SOC.-EC. IV–V			FEMALES—SOC.-EC. IV–V		
	North Eur.	*Italians*	*Total*	*North Eur.*	*Italians*	*Total*
A-form	5.4	14.5	9.0	22.2	20.8	21.8
B-form	21.3	32.3	25.6	34.9	50.0	39.1
D-form	39.3*	12.9*	28.8	25.4	16.7	23.0
S-form	34.0	40.3	36.5	17.5	12.5	16.1
	100.0	100.0	99.9	100.0	100.0	100.0
No. classified†	94	62	156	63	24	87

* Diff = 26.4; $\sigma_{diff} = 6.6$.

† The North European males included 70 per cent of all the North European IV–V males in the original data; North European females, 89 per cent of all North European IV–V females; Italian males, 75 per cent of the total Italian IV–V males; and Italian females 86 per cent of all Italian IV–V females.

NOTE.—Comparing Tables 2 and 3, it seems that the North Europeans of socio-economic class IV–V have a distribution of growth patterns more like the total North Europeans than like the Italians of the same socio-economic class. The differences between the North Europeans and Italians of the same socio-economic level are about the same order of difference as between the total ethnic groups. Likewise, the differences between males and females of the same socio-economic group (total of North Europeans and Italians IV–V) are of about the same order as the differences in the total males and females (cf. Table 1). The growth pattern may therefore be more related to sex and ethnic origin than to socio-economic level. (The Italians had relatively more lower class and fewer higher class than the North Europeans in the sample.)

Italians appear to have a markedly smaller percentage of D-curves, in both males and females, and a higher percentage of S-curves, as compared with North Europeans. Within the socio-economic classes IV-V, the Italians also may have a higher percentage of B-curves.

Ability-level and Form of Mental Growth Pattern

That the form of mental growth pattern may be related to the general level of ability is suggested by the distribution of ability within the different forms (Table 4, Figs. 10 and 11). The levels below N — 1 tend to be most often of the S-form, while the levels at N + 2 and above are most often of the D-form. Similar relationships are to be observed for both males and females, notwithstanding the fact that the incidence of the A-form was higher in the females and the incidence of the D-form lower.

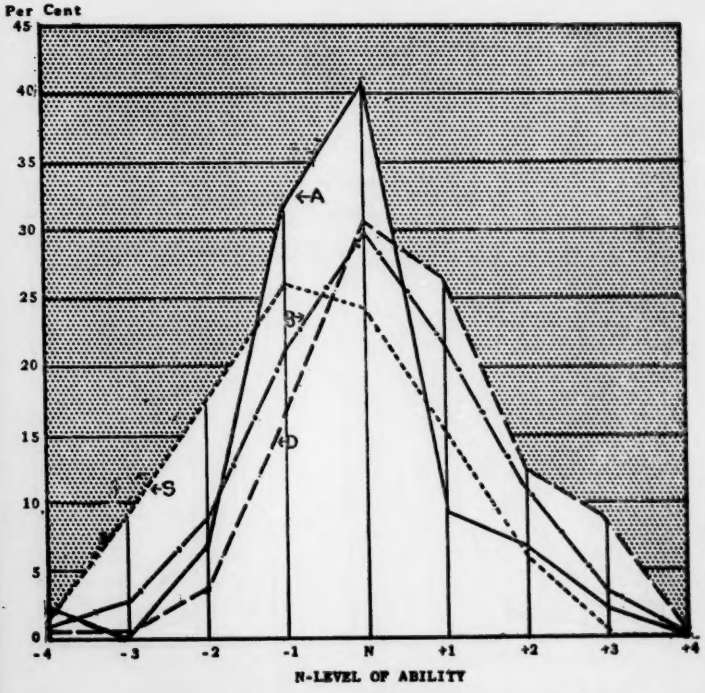

FIGURE 10—Percentage Distribution of Ability Level in Different Forms of Mental Growth Patterns—Males.

TABLE 4

PERCENTAGE DISTRIBUTION OF N-LEVELS OF ABILITY IN THE DIFFERENT FORMS OF MENTAL GROWTH PATTERN FOR THE TOTAL GROUPS OF MALES AND FEMALES

	MALES				FEMALES			
N-level	A	B	D	S	A	B	D	S
+4			0.7					
+3	2.3	3.5	8.6			1.8	3.4	1.2
+2	6.8	11.4	12.2	6.1	2.5	7.3	18.2	6.1
+1	9.1	21.9	26.4	15.3	22.8	26.6	29.5	17.1
N	40.9	29.8	30.7	24.4	34.2	30.3	29.5	28.1
−1	31.8	21.1	16.4	25.9	22.8	18.4	15.9	21.9
−2	6.8	8.8	3.6	17.6	11.4	12.8	2.3	14.6
−3		2.6	0.7	9.2	3.8	2.8	1.1	9.8
−4	2.3	0.9	0.7	1.5	2.5			1.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	99.9	100.0
No. of cases	44	114	140	131	79	109	88	82

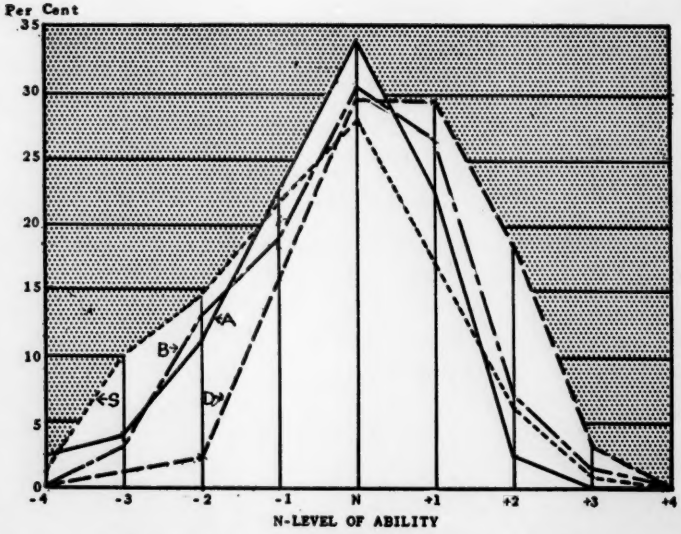

FIGURE 11—Percentage Distribution of Ability Level in Different Forms of Mental Growth Patterns—Females.

TABLE 5

PERCENTAGE DISTRIBUTION OF N-LEVELS OF ABILITY OF A, B, AND D FORMS OF MENTAL GROWTH PATTERN IN NORTH EUROPEANS, SOCIO-ECONOMIC CLASS III

	MALES			FEMALES		
N-level	A	B	D	A	B	D
+4			1.8			
+3	5.6	1.9	12.5		4.5	2.7
+2	5.6	7.5	8.9		4.5	13.5
+1		30.2	26.8	20.7	40.9	27.0
N	44.4	32.1	26.8	41.4	22.7	37.8
−1	33.3	22.6	16.1	24.1	18.2	18.9
−2	5.6	3.8	5.4	6.9	9.1	
−3				6.9		
−4	5.6	1.9	1.8			
Total	100.1	100.0	100.1	100.0	99.9	99.9
No. of cases .	18	53	56	29	22	37

TABLE 6

PERCENTAGE DISTRIBUTION OF N-LEVELS OF ABILITY OF B AND D FORMS OF MENTAL GROWTH PATTERN IN NORTH EUROPEANS AND ITALIANS, SOCIO-ECONOMIC CLASS IV

	MALES				FEMALES			
	B		D		B		D	
N-level	*No. Eur.*	*Ital.*	*No. Eur.*	*Ital.*	*No. Eur.*	*Ital.**	*No. Eur.*	*Ital.**
+4								
+3	6.3		3.2					
+2	12.5	12.5	9.7				21.4	
+1	18.7		19.4	25.0	35.7		42.9	25.0
N	25.0	25.0	45.1	62.5	28.6	25.0	28.6	50.0
−1	25.0	18.7	19.4	12.5	28.6	25.0		25.0
−2	12.5	25.0	3.2		7.1	37.5		
−3		18.7				12.5	7.1	
−4								
Total	100.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0
No. of cases	16	16	31	8	14	12	14	4

* The Italian female group includes socio-economic class V as well.

Differences in the distribution of ability in different forms persist to some extent even when the number of cases is reduced by subclassification (Tables 5 and 6; Figs. 12 and 13). In general, the distribution of D-forms shows a higher modal value and/or fewer cases at the lower levels, compared with the A- or B-forms.

Significance of Differences in Level of Ability

The chi-square test was applied to discover statistically significant differences in the ability level of groups having A-, B-, and D-forms of mental growth. Differences between A- and B-forms were not marked but the D-form clearly had a distribution of ability different from either A or B. This was true for both males and females combined, and for the group of North Europeans of socio-economic class III (See Table 7). The mean N-level is highest in the D-form. That is, the form of mental growth pat-

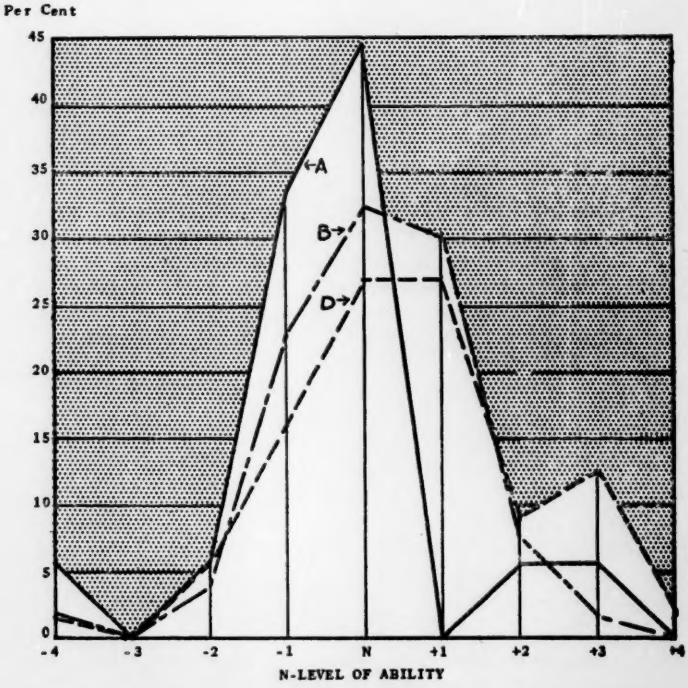

FIGURE 12—Percentage Distribution of Ability Level in Different Forms of Mental Growth—Males, North European, Socio-economic Class III.

tern which suggests the most rapid early development also seems to have the highest general level of ability.

Percentage of Maturity Attained at Different Ages in Different Forms of Mental Growth Patterns

Since the N-level was used to define the maturity-value toward which the individual was presumably developing, it follows that different forms of mental growth pattern might be expected to produce a different percentage of maturity-value at all or at least at certain ages. To discover what differences there might be, distributions of the percentage of maturity attained at ages 7, 9, 11, 13, 15, 17 and 19 were made according to the form of mental growth pattern. The individual values were read from the plotted lines at the point at which they crossed the abscissa at age 7-0, 9-0, etc. They are thus interpolated values for an exact age and not the actual values

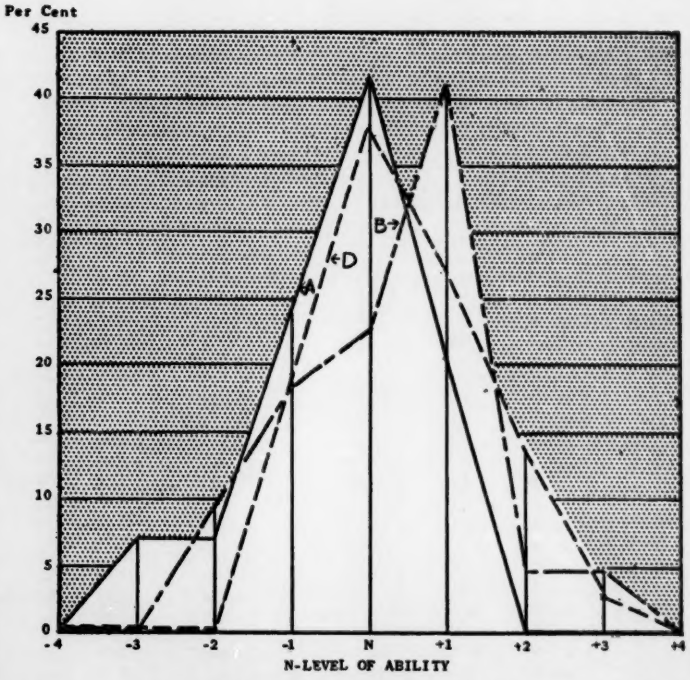

FIGURE 13—Percentage Distribution of Ability Level in Different Forms of Mental Growth—Females, North European, Socio-economic Class III.

TABLE 7

MEAN N-LEVEL AND SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS OF DIFFERENT GROUPS

	Group	*No. of Cases*	*Mean N-level*
1	Combined grand total	355	+ .27
2	Combined males	209	+ .32
3	Combined females	146	+ .20
4	All A curves — males	29	− .86
5	All A curves — females	43	− .20
6	All B curves — males	85	+ .15
7	All B curves — females	48	− .02
8	All D curves — males	95	+ .61
9	All D curves — females	55	+ .71
10	A curves, NE III, females	29	− .17
11	B curves, NE III — males	53	+ .39
12	B curves, NE III — females	22	+ .46
13	D curves, NE III — males	56	+ .76
14	D curves, NE III — females	37	+ .73
15	Combined Ital. IV — M & F	53	− .54
16	Combined Ital. IV — males	32	− .44
17	Combined Ital. IV — females	21	− .69
18	Combined NE IV — M and F	87	+ .36
19	Combined NE IV — males	50	+ .39
20	Combined NE IV — females	37	+ .32

Groups Compared	*Chi Square*	*p*	*Groups Compared*	*Chi Square*	*p*
2 and 1	3.58	.95	Total 6+7 and 8+9	59.65	.001
3 and 1	4.33	.95–.90	10 and 3	4.73	.10
4 and 2	2.60	.30	11 and 2	4.09	.50
5 and 3	2.30	.70	12 and 3	1.88	.70–.50
6 and 2	5.50	.70–.50	13 and 2	11.86	.05
7 and 3	2.93	.50	14 and 3	9.42	.10
8 and 2	4.56	.80	16 and 2	10.89	.02
9 and 3	12.75	.02	17 and 3	15.51	<.001
4 and 6	0.89	.70	16 and 15	0.72	.90–.80
5 and 7	1.12	.80	17 and 15	1.08	.50
Total 4+5 and 6+7	10.97	.10	19 and 2	2.11	.90
8 and 4	8.80	.01	20 and 3	4.25	.20
9 and 5	20.92	.001	19 and 18	3.43	.80–.70
Total 8+9 and 4+5	38.31	.001	20 and 18	4.22	.20
6 and 8	20.69	.01			
7 and 9	22.70	.001			

plotted at intermediate age-points. The values for age 19 are for the most part extrapolated from the slope of the line, since only a small percentage of cases had records extending to age 19, although many had final measurements beyond 18.5 years

Figures 14 and 15 show the mean percentage of maturity at ages 7 to 19 for the males and females of the A-, B-, and D-forms of mental growth patterns in the North European III group. In Figures 16, 17 and 18, the males and females of each form are compared. These curves reveal the general characteristics of the three forms of growth curves. The A-form is a straight line, the line for males and females almost but not quite coinciding and the means for age 17 being slightly out of line. The B-form gives a straight line from age 7 to age 11, for both males and females, then a slightly decreased slope to age 15 for females and to almost 16 for males, at which points a sharp upturn in the slope occurs. The D-form has a slightly steeper slope to age 13, a markedly decreased slope to 16 for females and to 17 for males, at which points an upturn again occurs but at a lower slope than that of the first line.

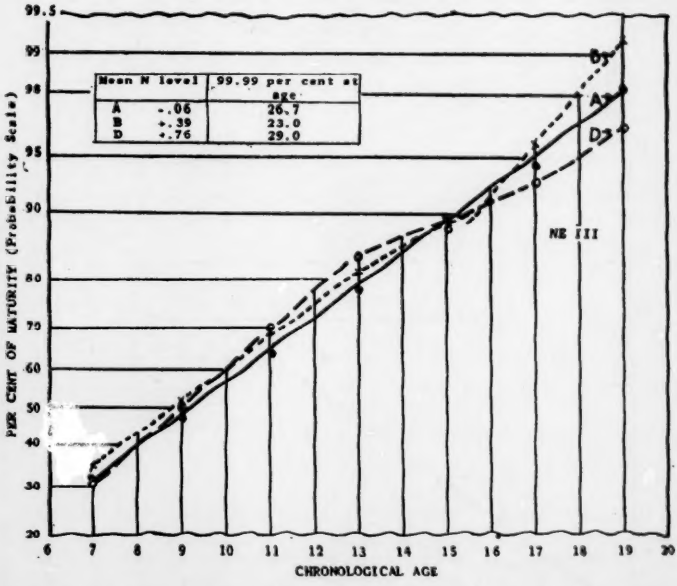

FIGURE 14—Mean Per Cent of Maturity at Ages 7 to 19 in Different Forms of Mental Growth Pattern for North European Males, Socio-economic Class III.

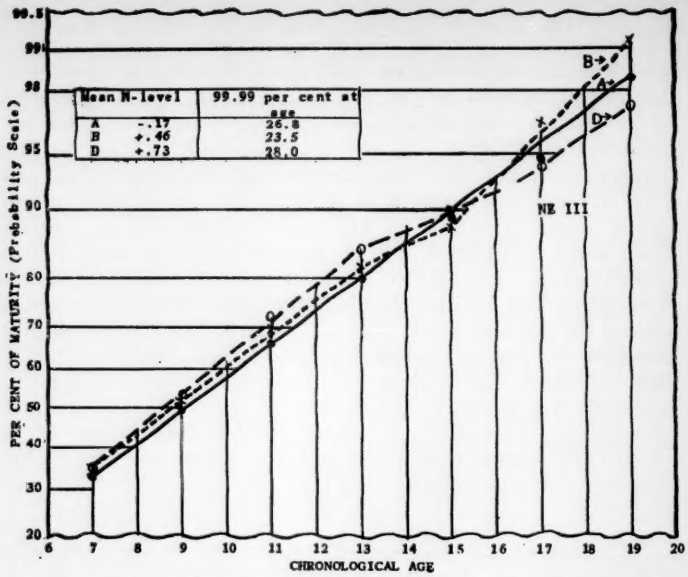

FIGURE 15—Mean Per Cent of Maturity at Ages 7 to 19 in Different Forms of Mental Growth Pattern for North European Females, Socio-economic Class III.

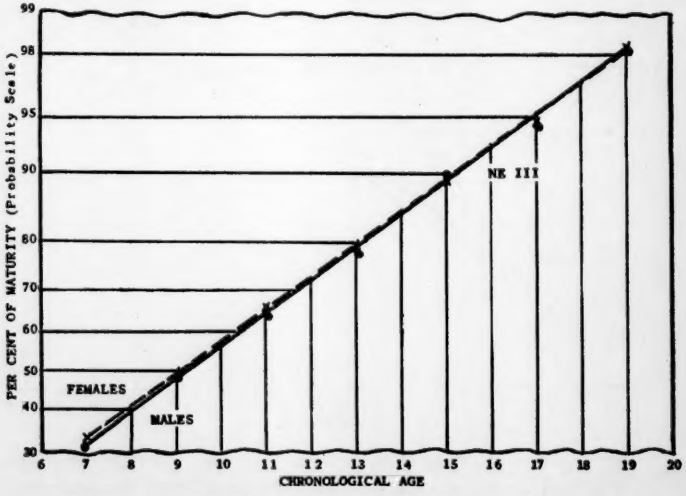

FIGURE 16—Generalized A-form of Mental Growth Pattern.

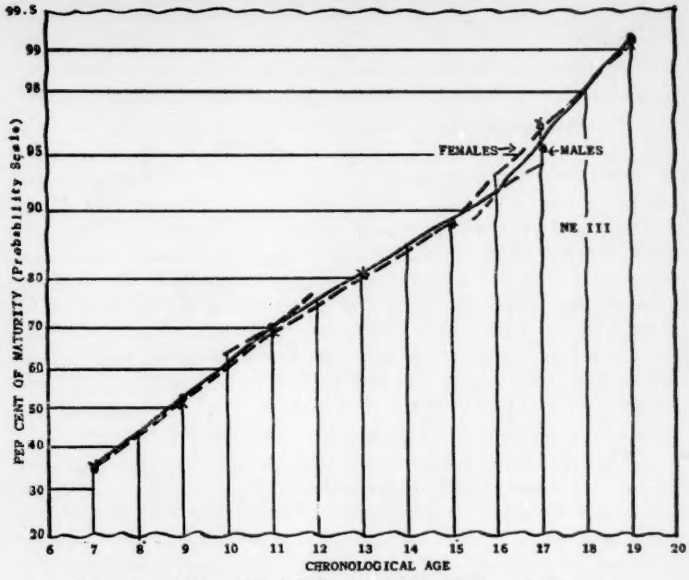

FIGURE 17—Generalized B-form of Mental Growth Pattern.

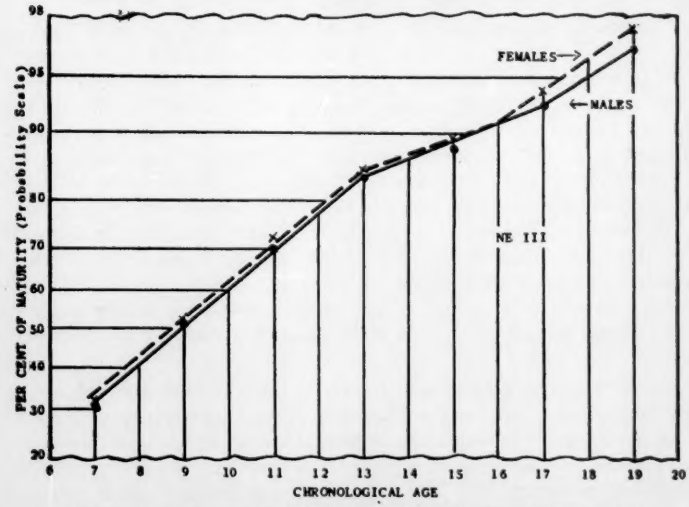

FIGURE 18—Generalized D-form of Mental Growth Pattern.

Summary of Characteristics of A-, B- and D-Forms of Mental Growth Pattern

These patterns are sufficiently clear-cut to give validity to the individual classification on this basis. The points of particular interest about them are:

1. The mean percentage of maturity at age 7 on all types and for both males and females is between 31 and 35 per cent. The B-form has the highest percentage at age 7. At age 9, the mean value for both B-and D-forms is 52 per cent, while the A-form mean value is just under 50 per cent. At 13, the D-form has attained 84 per cent of maturity, the B-form 82 per cent and the A-form just under 80 per cent. Up to age 15, the males and females of any form have almost identical curves, though the different forms are distinguishable. By age 19, the value for the A-form is 98.2 per cent, identical for males and females. The B-form has reached 99.2 per cent for males, 99.1 per cent for females at age 19, while the D-form is just under 97 per cent for males and about 97.5 per cent for females. It must be remembered, however, that the mean *level* of maturity toward which the different forms are moving is different, D being the highest level, B next, and A last.

2. The relationships would suggest that individuals of the A-form do not, for some reason, experience the adolescent variations that occur in the B- and D-forms. Maturity (99.99 per cent) would not be reached according to this form, on the average, until age 26.7 for males and 26.8 for females. The mean maturity level of the A-form has a value just slightly below the maturity level indicated by the N position (that is the theoretical norm) of the original mental age semi-log curve.

The mean patterns of the B-form and the D-form have slightly different slopes up to age 13, so that by age 13 the D-form has reached a slightly higher percentage of maturity. After this it proceeds more slowly, the females showing a slightly higher percentage of maturity than the males at each age thereafter. From 17 to 19 the slope increases again, but slowly. Projecting the D-form to 99.99 per cent of maturity would indicate full maturity for females at age 28 and for males at age 29. The mean N-level of the D-form is +.76 for males and +.73 for females. The B-form has a slightly lower slope to age 13 but begins a more rapid increase toward maturity earlier than the final rise in the D-form. It also occurs a year earlier in females than in males, but males and females reach almost the same percentage point at age 19. The slope of the B-form in later adolescence would indicate maturity for males at age 23 and for females at about 23.5.

3. In terms of percentage of maturity, the three patterns of growth may be summarized as follows: (*a*) Those who develop according to the A-pattern have a single growth curve theoretically reaching maturity between ages 26 and 27, maturity being indicated by a mean level of ability regarded as just about average. (*b*) Those who develop according to the B-pattern have two growth curves during this period, the earlier one terminating

around age 13, on the average, the second one not becoming evident until age 15 or 16, with maturity theoretically indicated at about 23 to 24 years of age, at a level slightly above average. (*c*) Those who develop according to the D-pattern have the most rapid development from 9 to 13, the longest period of slow increase and a late maturity theoretically reached at 28 to 29 years of age, at the highest mean level of ability of any form. Table 8 summarizes the differences.

From a theoretical consideration of patterns of growth, the identification of these patterns of mental growth has considerable interest when compared with patterns of bacterial growth recently pointed out. C. B. Van Niel, studying growth curves of micro-organisms, has discovered two types of growth which he describes as follows:

> Depending upon the nature of the organism and of the substrates [i.e., the median of the cultures] either of two types of growth curves describes the observed response of the bacteria. One represents a single period of exponential growth extending over the entire time interval during which the substrate is available, with the sharp break at the end marking the complete utilization of the two carbon sources. The other kind consists of two distinct parts, each in itself a characteristic growth curve, with its phases of accelerated, maximal and retarded growth rates, the two curves being conspicuously separated by a horizontal stretch which indicates the cessation of growth during the corresponding period (3, p. 101).

The first type of growth corresponds to the A-form of mental growth pattern; the second corresponds to the B_4-form and probably also to the D_{22}- and perhaps the D_{16}-forms. Van Niel showed that the first phase of the second type of growth curve corresponded to the utilization of only one of the two substrates, that the second growth curve coincided with the utilization of the second substrate and that the length of the "horizontal stretch" depended on the ratio of concentration of the two substrates and presumably represented the interval needed for the bacteria to adapt themselves to the utilization of the second substrate. The rather startling similarity to the patterns of mental growth (which were identified empirically without knowledge of the bacterial research) suggests many speculative hypotheses about mental growth which transcend the possibilities of verification in the present study.

Subforms of Mental Growth Patterns

1. When the forms are subdivided into the B_3-, B_4-, D_{14}-, D_{16}-, and D_{22}-forms of mental growth pattern, there is evidence of some persistence of these patterns both in the distribution of patterns in various ethnic-socio-economic groups and in the general N-level of those whose patterns are of different forms. Based on the total of 429 males and 358 females from all the ethnic-socio-economic groups, the distribution of the subforms is shown in Table 9. In the total group, excluding for the present those whose growth patterns were classified in the S group (approximately 30 per cent

TABLE 8

COMPARISON OF MEAN MENTAL GROWTH PATTERNS OF FORMS A, B, AND D IN NORTH EUROPEANS OF SOCIO-ECONOMIC CLASS III

Form	*Age at End of First Cycle*		*Per Cent of Maturity at Age 13*		*Age at Beginning of Late Cycle*		*Projected Age at Maturity (99.99%)*		*N-level of Ability*		*Per Cent of NE III Cases of Each Form**		All Cases Classified as to Form: *Mean N-level*		*Per Cent of Cases of Each Form†*	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
A	..	..	78	79	...	...	26.7	26.8	−.06	−.17	12.0	30.8	−.09	−.20	10.1	22.1
B	13	13	82	82	15.9	15	23	23.5	+.39	+.46	35.3	23.4	+.15	−.02	27.6	30.4
D	13	13	84	84.5	17	16	29	28	+.76	+.73	37.3	39.4	+.61	+.71	32.2	24.6

*The number of North European III males and females classified was 150 and 94 respectively. Of these, 15.3 per cent of males and 6.4 per cent of females were classified as S-form.

† In addition to A, B, and D-forms, 30.1 per cent of all males and 22.9 per cent of all females were classified as S-form.

TABLE 9

DISTRIBUTION OF VARIOUS SUB-FORMS OF MENTAL GROWTH PATTERN

Form	Total				NE III				NE IV				ITAL IV*			
	Number of Cases		*Per Cent*		*Number of Cases*		*Per Cent*		*Number of Cases*		*Per Cent*		*Number of Cases*		*Per Cent*	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
A	44	79	14.8‡	28.6‡	18	29	14.2§	32.9**	3	9	6.0§†	24.3††	8	5	25.0	23.8
B_3	22	33	7.4	12.0	9	7	7.1	8.0	1	5	2.0¶	13.5	7	7	21.9¶	33.3
B_4	92	76	30.9	27.5‡‡	44	15	34.6	17.0‡‡	15	9	30.0	24.3	9	5	28.1	23.8
D_{14}	57	32	19.1	11.6	19	10	15.0	11.4‖	13	11	26.0	29.7‖	3	2	9.4	9.5
D_{16}	41	25	13.7	9.1	20	16	15.7	18.2	9	0	18.0	0	1	0	3.1	0
D_{22}	42	31	14.1	11.2	17	11	13.4	12.5	9	3	18.0	8.1	4	2	12.5	9.5
Total A+B+D ..	298	276	100.0	100.0	127	88	100.0	100.0	50	37	100.0	99.9	32	21	100.0	99.9
S	131	82														
Total	429†	358†														

* The Italian IV, Female, group was so small that this group includes also Italian V.

† The total number of cases includes the entire sample of all socio-economic groups except North European III from which an unselected sample was chosen. South Europeans and Jews, as well as North Europeans and Italians, were included in the total.

‡ Diff. = 13.8; σ_{diff} = 3.3. ¶ Diff. = 19.9; σ_{diff} = 7.6. ** Diff. = 18.7; σ_{diff} = 5.8. ‡‡ Diff. = 10.5; σ_{diff} = 4.8.

§ Diff. = 8.2; σ_{diff} = 4.5. ‖ Diff. = 18.3; σ_{diff} = 13.0. †† Diff. = 18.3; σ_{diff} = 7.9.

of all the males and 23 per cent of all the females), the B_4-pattern is the predominant male pattern, but the females have almost the same proportions of A- and B_4-patterns. Females have a significantly larger proportion of the A-form than do males. The B_3-form is by far the least frequent pattern in the males but in the females has approximately the same frequency as both the D_{14}- and the D_{22}-forms. The North European III males follow closely the total male distribution of patterns, but the North European III females have more A's and fewer B_4's than the total females.[6] In the North European IV group, males lose in the proportion of A's and gain in the proportion of D_{14}'s, while females gain in proportion of D_{14}'s but have none of the D_{16}-form. The Italian IV groups are too small to have much stability, but D_{16} in both males and females appears to be almost lacking in this group, and B_3 to have a higher frequency among both males and females than in other groups.

2. Among the various ethnic-socio-economic groups of males, the median N-level of the different forms of mental growth pattern shows a rather consistent tendency for the D_{22}-form to have the highest ability, the B_3 to have the lowest, the A and the D_{16} to be close to average expectancy. The females are less consistent but show generally similar tendencies (Table 10). The differences between B_3 and B_4 suggest that these are essentially different patterns and should not be combined under a generalized B-form.

Mental Growth Patterns of the S-Form

1. The forms of mental growth pattern first analyzed revealed the A, B_3, B_4, D_{14}, D_{16}, and D_{22} patterns with sufficient definitiveness so that there was not much question as to their classification. Other tentative categories were tried out but abandoned because they appeared ambiguous. After the group of 209 males and 146 females comprising the six A, B and D patterns were analyzed, the unclassified cases were reviewed and the step-wise progress which was observed in many cases was used as a further basis for classification. Five subdivisions of this classification were made:

$S_{D_{10}}$—Those whose plotted curves on probability paper showed a general D-form, but the childhood period showed a break beginning at age 10 or earlier, followed by a fairly sharp rise to the point at which the adolescent pattern began.

$S_{D_{11}}$—Those whose pattern was of a general D-form, with a break beginning at age 11 or later, followed by a fairly sharp rise to the beginning of the adolescent pattern.

S_A—Those whose pattern was step-wise around a general trend of the A-form.

[6] The North European III males accounted for 42.6 per cent of the total males of A, B and D patterns, while the North European III females accounted for only 31.9 per cent of the total females of A, B and D patterns.

TABLE 10

MEDIAN N-LEVEL OF VARIOUS SUB-FORMS OF MENTAL GROWTH PATTERN

Form	*Total*		*North European III*		*North European IV*		*Italian IV*		*Combined NE III IV, Ital. IV*	
	M	F	M	F	M	F	M	F	M (209)	F (146)
A	− .05	− .06	+ .08	− .06	(.00)	(.00)	(− .50)	(−1.00)	− .10	− .08
B_3	−1.00	−1.00	− .50	− .13	(−1.00)	(+ .88)	(−2.13)	(−1.63)	−1.13	− .88
B_4	+ .53	+ .32	+ .90	+ .94	+ .17	(.00)	(− .17)	(− .17)	+ .44	+ .88
D_{14}	+ .66	+ .75	+ .80	+ .50	+ .20	+1.10	(+ .13)	(+ .25)	+ .38	+1.11
D_{16}	+ .20	+ .81	+ .13	+ .75	(− .33)	.....	(+1.00)	.....	+ .15	+ .75
D_{22}	+1.02	+ .79	+1.62	+ .63	(+1.00)	(.00)	(.00)	(+ .25)	+1.13	+ .42
All cases	+ .11	+ .11	+ .88	+ .33	+ .17	+ .69	− .19	− .67	+ .23	+ .23

NOTE.—Medians of fewer than 10 cases are enclosed in curves. Number of cases is shown in Table 9.

TABLE II

PERCENTAGE DISTRIBUTION OF SUB-FORMS OF MENTAL GROWTH OF THE S-PATTERN IN THE TOTAL GROUP, IN THE DIFFERENT ETHNIC GROUPS AND IN SOCIO-ECONOMIC CLASSES III AND IV

(Number of Cases Shown in Parentheses)

Form	*All Groups*		*North Europeans*		*Italians*		*South Europeans*		*Jews*		*III (All Ethnic)*		*IV (All Ethnic)*	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
S_A	35.9	24.4	36.6	33.3	35.9	16.2	36.4	22.2	30.0	33.3	39.0	26.3	25.7	25.0
	(47)	(20)	(26)	(8)	(14)	(6)	(4)	(2)	(3)	(4)	(16)	(5)	(9)	(4)
S_B	18.3	20.7	11.3	4.2	25.6	32.4	27.3	33.3	30.0	8.3	12.2	15.8	20.0	12.5
	(24)	(17)	(8)	(1)	(10)	(12)	(3)	(3)	(3)	(1)	(5)	(3)	(7)	(2)
S_E	15.3	24.4	11.3	20.8	23.1	32.4	9.1	22.2	20.0	8.3	9.8	21.0	22.8	25.0
	(20)	(20)	(8)	(5)	(9)	(12)	(1)	(2)	(2)	(1)	(4)	(4)	(8)	(4)
$S_{D_{10}}$	13.0	21.9	14.1	25.0	5.1	13.5	27.3	11.1	20.0	50.0	14.6	31.6	8.6	25.0
	(17)	(18)	(10)	(6)	(2)	(5)	(3)	(1)	(2)	(6)	(6)	(6)	(3)	(4)
$S_{D_{11}}$	17.6	8.5	26.7	16.7	10.3	5.4	....	11.1	....	....	24.4§	5.3§	22.8	12.5
	(23)	(7)	(19)	(4)	(4)	(2)	(0)	(1)	(0)	(0)	(10)	(1)	(8)	(2)
Total S	100.1	99.9	100.0	100.0	100.0	99.9	100.1	99.9	100.0	99.9	100.0	100.0	99.9	100.0
	(131)	(82)	(71)	(24)	(39)	(37)	(11)	(9)	(10)	(12)	(41)	(19)	(35)	(16)
Total Group	(429)	(358)	(279)	(193)	(87)	(105)	(30)	(17)	(33)	(43)	(189)	(132)	(86)	(86)
Per Cent S	30.5*	22.9*¶	25.4†	12.4†	44.8	35.2	36.7	52.9¶	30.3	27.9	21.7	14.4	40.7‡	18.6‡

* Diff = 7.6; σ_{diff} = 3.2.
† Diff = 13.0; σ_{diff} = 3.3.
‡ Diff = 22.1; σ_{diff} = 6.7.
§ Diff = 19.1; σ_{diff} = 8.3.
¶ Diff between So. Eur. and total females = 30.0; σ_{diff} = 12.3.

NOTE.—The North European females of the S-form comprise 29.2 per cent of all females of the S-form (24 out of 82), while all North European females comprise 53.9 per cent of all females (193 out of 358); diff = 24.7; σ_{diff} = 5.6. The comparable difference for males = 10.8; σ_{diff} = 5.9.

S_B—Those whose pattern was step-wise around a general trend of the B-form.

S_E—Those whose most marked characteristic was a plateau in childhood—a flat period like the B_4-pattern—but occurring before the beginning of the adolescent break.

2. The distributions of the S- subforms for various ethnic and socio-economic groups are shown in Table 11. There were 131 males in the supplementary group and 82 females classified as S-forms, which was 30.5 per cent of all males classified and 22.9 per cent of females. The difference is possibly significant, being more than twice the sigma of the difference. The difference between the proportions of males and females classified as S in the North European ethnic group is statistically significant, about a quarter of the North European males and only half that proportion of females falling in the S-form. The proportion of females of the S-form which is in the North European classification is also significantly smaller than the proportion of all females which is North European. Males tend in the same direction. It therefore would seem that S-forms are less characteristic of females than of males, and less characteristic of the North European than of other groups.

3. Subdividing the S-form, the differences found are not large enough to be statistically significant with the small number of cases, but a few interesting trends are shown: (*a*) Although in the distribution of A-, B-, and D-forms, more females than males were of the A-form, the S_A-form has a larger proportion of the S-forms among males than among females—in the total, in the Italians, in the South Europeans, in socio-economic class III, although not conspicuously in North Europeans and not perceptibly in socio-economic class IV. (*b*) For the total, for North Europeans, for Italians, and for both socio-economic classes III and IV, more males are of the $S_{D_{11}}$-form than of the $S_{D_{10}}$-form, while more females are of the $S_{D_{10}}$-form than $S_{D_{11}}$. This suggests that the age at which a spurt toward the beginning of the adolescent curve occurs, when there has been a period of hesitation, may be related to the earlier maturity of girls. It is possible that this phenomenon may be found in other forms of curve, even if less marked, and may afford a basis for classification that will aid in prediction.

4. The reversal of the proportions of males and females showing patterns of the distinctive A-form and of the less-distinctive A-form in the S series suggested that there might be no difference in the proportions of males and females having different forms of mental growth pattern other than the greater tendency of males to have more irregular development showing up as a step-wise pattern. However, even when the S_A-, S_B- and S_D-forms are added to the A-, B- and D-forms respectively, there is still a tendency for the females to have more A's and for males to have more D's (Table 12).

TABLE 12

DISTRIBUTION OF A, B AND D FORMS OF MENTAL GROWTH PATTERN WHEN S_A, S_B AND S_D ARE INCLUDED

Form	*Males* No. of Cases	Per Cent	*Females* No. of Cases	Per Cent
A	44		79	
S_A	47		20	
Total A	91	22.2*	99	29.3*
B	114		109	
S_B	24		17	
Total B	138	33.7	126	37.3
D	140		88	
S_D	40		25	
Total D	180	44.1†	113	33.4†
A+B+D	409	100.0	338	100.0
S_E (Not included above)	20		20	
Total classified	429		358	

* Diff = 7.1; $\sigma_{diff} = 3.2$.
† Diff = 10.7; $\sigma_{diff} = 3.5$.

TABLE 13

MEDIAN N-LEVEL OF S-FORMS COMPARED WITH OTHER FORMS OF MENTAL GROWTH PATTERNS

S-Forms	*Males*	*Females*	A, B, D-Forms	*Males*	*Females*
S_A	− .50	− .50	A	− .05	− .06
S_B	− .25	− .33	B_3	−1.00	−1.00
			B_4	+ .53	+ .32
S_{D10}	+ .83	+ .88	D_{14}	+ .66	+ .75
S_{D11}	−1.79	− .50	D_{16}	+ .20	+ .81
			D_{22}	+1.02	+ .79
S_E	+ .59	− .92			
All S	− .40	− .19	All cases	+ .11	+ .11
Total number	131	82	Total number	429	358

5. The median N-level of the S-form curves tends to be somewhat below the general expectation, for the total groups of males and females and for each form except the S_{D10} (Table 13). When the S_A-form is compared with the A-form, the median N-level is also lower. Since the S_B-form was not divided into the B_3- and B_4-forms, and the S_D-forms were divided on

a different basis from the D-forms, direct comparisons are not possible. If the S-forms tend to be lower, the implication might be that the step-wise patterns indicate temporary interferences with normal growth, from which recovery is at an accelerated rate, although the acceleration is not sufficient to compensate completely for the retardation.

Discussion of Implications

The concept of mental growth has developed from cross-sectional studies of children of different ages and has led to some assumptions which are not borne out by longitudinal studies of the same children over a long period of years. The basic assumption is that the average child (IQ of 100) "grows" mentally at an even rate and that the work of each grade adds an equal increment of difficulty to the grade preceding so that the average child can cope successfully, with reasonable expenditure of effort, with the graded system, progressing regularly one grade in one year, as his mental ability "grows" one year of "mental age" each year. It is further assumed that any IQ expresses the rate of growth. For example, the child whose IQ is 130 "grows" mentally 1.3 years of "mental age" each year, and the child with an IQ of 70 "grows" 0.7 years of "mental age" each year.

The school which has given attention to individual differences realizes that children have different degrees of readiness for learning the 3R's when they enter school. The "mental ages" of six-year-olds vary from the readiness that might be expected of an average three- or four-year-old to the readiness that might be expected of an average eight- or nine-year-old. Before the advent of mental tests, schools dealt with these differences by accelerating and retarding pupil's grade progress. The bright children were skipped over a whole grade or over one term at a time so that they were placed at a point nearer their readiness for learning the content "appropriate" for a given grade. The dull children were held back in each grade until either they grew in mental maturity to the point of readiness for learning at that grade level of difficulty or, by sheer repetition, remembered enough to give back, parrot-wise, enough of the content to simulate understanding.

Since the advent of mental tests, and particularly of diagnostic educational tests, the basic method of dealing with individual differences has changed. The accepted ideal practice now is to keep children moving through the grades with the group with which they entered school and to modify the teaching according to the readiness of the different children of each grade group (now, essentially, each age group). The ideal practice is better carried out in its promotional aspect than in its teaching aspect, largely because the curriculum objective, at least for the elementary and probably for the junior high school, is still based on the concept of a common body of content desirable for all, and an arrangement of this content according to the traditional graded system.

If it is true, as educators now believe, that children have emerging new needs in their early adolescence, then *chronological age is not an adequate basis for assigning the grade level* at which these needs are to be provided for, because individual children vary in the age at which evidences of adolescence appear from about age 11 to about age 15. There is a group difference between boys and girls of about two years, so that even *on the average* what girls need at age 12 is what boys are not ready for until age 14, so far as emerging adolescent needs are concerned. This aspect of individual differences has not yet had much influence on educational planning.

If the patterns of mental growth vary as suggested by this analysis of the Harvard growth data, then not only the emotional and physical needs of adolescence need to be provided for at the appropriate time for different individuals, but also *adolescent changes in the pattern of intellectual maturation demand consideration.*

This will require some fundamental rethinking about the content of the school curriculum, particularly for the early adolescent period. First, comprehensive and adequately processed records of growth, both physical and mental, are needed to verify or refute the present findings. Then, the implications of this longitudinal approach for school practices will need thorough study. Considering that the Harvard data were gathered from 1922 to 1934, that the mental tests used were not strictly comparable and were perhaps cruder measures than are available today, that the school program for young adolescents in 1930 was less differentiated from the elementary program than it has since become, and that no data about school achievement or social and emotional factors were available for the present analysis, it is clear that the present study can go no farther than presenting tentative hypotheses.

It is conceivable, though it does not seem highly probable, that if school experiences were provided which adequately met the needs of all pupils, a very much larger percentage of pupils might develop according to the A-pattern of mental growth—a single, continuous growth curve with increasing and decreasing increments from school entrance to school leaving. The fact that more girls than boys followed this pattern and the generally accepted idea that girls have adapted themselves to the traditional school program better than boys make this interpretation a possibility not to be ignored.

The question of *whether the gap between the end of the childhood cycle of mental growth and the beginning of the adolescent cycle,* marked by a period of no mental growth in early adolescence, which is clearly observable in the B_4-pattern and in a third or more of the D-patterns, *is an inherent phenomenon of certain patterns of mental growth or is the result of the kind of school curriculum provided should also be further explored.* In either case it should have a profound influence upon our thinking about the needs of young adolescents. If it is an inherent phenomenon of growth, then those who develop according to patterns of this type must undergo a

period of exceptional stress and strain under a school program set up on the theory of increasing learning-difficulty from year to year during this period. Such an interpretation might explain some of the adolescent breakdowns which appear to be increasing in frequency at the same time that the holding power of the high school is also increasing. If it is not an inherent phenomenon of growth but is the result of certain types of experience, then the school program for at least half of the school population does not provide appropriate experience. It may be that in schools in which the program has been modified to meet the "life-adjustment" needs of boys and girls we shall find a sharp decrease in the percentage of those who appear to mark time intellectually in early adolescence. If we do not find such a drop under such an educational program, it may be that other aspects of growth are dominant over intellectual growth at this period and that the program should minimize, for pupils of this type, the stress on academic accomplishment, while expanding the opportunities for social, emotional and ethical development. We need longitudinal records of pupils over a wide area of behavior so that the interrelationships of adolescent development may be made clearer.

Longitudinal records which clearly show both physical and mental growth trends will become of increasing importance with our increasing knowledge of psychosomatic interrelations and their effects on physical and mental health and growth. It is quite possible that children who have specific vitamin deficiencies, hormone deficiencies and endocrine gland dysfunctions may be more easily screened for needed medical attention by observation of irregularities in their growth patterns in height, weight and mental ability than by other methods available in schools. The S-patterns of the present analysis could possibly be indicative of interruptions in the pattern of mental growth due to such causes. If good longitudinal records are available, they may be of diagnostic significance as school health services become alerted to their value.

There are implications for guidance in the findings of the present study. It would appear that *mental tests given between the ages of 11 and 15 may be quite ambiguous as prognostic devices if they are not considered in the light of the total growth curve.* For example, if the test given at age 12 is on the childhood cycle and the adolescent pattern is not yet clear, we can not tell whether adolescent development will be relatively rapid or slow. On the other hand, if a test at age 12 giving the same score already indicates a change of direction on the adolescent cycle, it may have a different significance with respect to the ultimate maturity of the individual. The Harvard growth data suggest that the tests given between ages 7 and 10 are more likely to be indicative of the adult mental maturity level than tests between 11 and 15, although not of the rate or pattern of later development nor of the age at which maturity may probably be reached. It seems probable that in some cases, the expected maturity level would be overestimated at these ages, while in other cases it would be under-

estimated. If counseling about college or choice of a vocation, or even about selection of senior high school courses, is to begin before age 15, it should be clearly tentative and programs should be flexible enough to permit changes to be made easily. To achieve the necessary flexibility within the secondary school, college entrance requirements might need to be modified so that college requirements would not impose a rigidity of scheduling courses through grades 9 to 12 which would prevent the "late developers" from meeting college entrance requirements.

Since many studies have indicated that the average mental age of adults appears to be about that of an unselected cross-section of 14- or 15-year-olds, we have been too ready to assume that mental ability does not increase beyond the *chronological* age of 15. Most of the individuals in the Harvard study whose records went beyond age 16 showed growth in mental ability from 16 to 17 and from 17 to 18, although a large proportion of them had two or three years of little or no growth in mental age preceding this. Many of these curves suggest that it might be better for some individuals to have a period of work experience between 14 and 17 and a return to academic study later than to be forced to conform to our present pattern of continuing academic study to age 16 or 17, with its inevitable frustrations, thereby cutting off any interest in or expectation of further academic achievement. The work-study plan of some high schools may be a significant step in this direction.

The rather large group difference between boys and girls in the age at which they reach the adolescent cycle of growth may suggest to some that boys and girls during the years in which these changes are occurring could more profitably be segregated educationally than taught in the same classes at the same age. However, the wide variations in age of the beginning puberal change within either sex make the problem more complex. If early secondary education is intended to meet the needs of young adolescents, *it would seem logical to classify pupils by their growth patterns rather than by chronological age*. It would require a radical change in our whole school structure, however, to provide appropriate elementary education for some children up to age 11 and for others up to age 15. Perhaps, however, we should look forward to some change in this direction.

Before we can be sure of the nature and of the significance of different patterns of mental growth, we shall need to accumulate longitudinal pupil records in a variety of school situations and to process these records so that they can be easily interpreted. Almost every school now keeps a cumulative pupil record, which often accompanies the child as he moves from elementary school to high school. It would be rare, however, to find a pupil record which showed at a glance the pattern of the child's growth. The present study affords a basis for keeping such graphic records in any school which has an annual testing program and keeps annual records of the height and weight of children. By a process of statistical control and classification, some of the erratic variations in measurement were reduced

in the present study. Individual patterns thus became clear enough to be classified. The application of these techniques would be within the resource limits of many schools. It is believed that they would be of considerable value for understanding individual children currently, and the accumulation of comparable records from a variety of schools should in time yield a body of data that could add a significant chapter to our knowledge of mental growth and of the interrelationships of the total growth process.

Appendix

TABLE FOR CONVERSION OF MENTAL AGES TO CMA UNITS
(M.A. in Months)

Tens of Months (M.A.)	Units of Months (M.A.)									
	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
6	18.0	18.5	19.0	19.5	20.0	20.5	21.0	22.0	22.5	23.0
7	23.5	24.0	25.0	26.0	27.0	27.5	28.0	28.5	29.0	29.5
8	30.0	30.7	31.4	32.0	33.0	33.5	34.0	34.7	35.4	36.0
9	37.0	37.5	38.0	39.0	40.0	41.0	42.0	43.0	44.0	44.6
10	45.2	45.8	46.5	47.2	48.0	48.7	49.5	50.2	51.0	51.8
11	52.6	53.4	54.2	55.0	55.8	56.5	57.2	57.9	58.6	59.3
12	60.0	60.8	61.6	62.4	63.2	64.1	65.0	65.7	66.4	67.0
13	67.7	68.4	69.0	69.7	70.4	71.1	71.8	72.4	73.0	73.7
14	74.4	75.1	75.8	76.4	77.0	77.5	78.0	78.5	79.0	79.5
15	80.0	80.6	81.2	81.8	82.4	83.0	83.6	84.0	84.4	84.8
16	85.2	85.6	86.0	86.5	87.0	87.5	88.0	88.5	89.0	89.5
17	90.0	90.5	91.0	91.3	91.6	92.0	92.3	92.6	93.0	93.4
18	93.7	94.0	94.3	94.6	94.9	95.2	95.4	95.7*	96.0	96.3
19	96.6	96.9	97.3	97.6	98.0	98.3	98.6	98.9	99.2	99.5
20	99.8	100.1	100.4	100.7	101.1	101.4	101.7	102.0	102.3	102.7
21	103.0	103.3	103.6	103.9	104.2	104.5	104.9	105.2	105.5	105.8
22	106.1	106.4	106.8	107.1	107.4	107.7	108.0	108.3	108.7	109.0
23	109.3	109.6	109.9	110.3	110.6	110.9	111.2	111.5	111.8	112.2
24	112.5	112.8	113.2	113.5	113.8	114.1	114.4	114.7	115.0	115.4
25	115.7	116.0	116.3	116.6	116.9	117.2	117.5	117.8	118.2	118.5
26	118.8	119.2	119.5	119.8	120.1	120.4	120.7	121.0	121.4	121.7
27	122.0	122.3	122.6	122.9	123.2	123.5	123.9	124.2	124.5	124.8
28	125.1	125.5	125.8	126.1	126.4	126.7	127.0	127.3	127.7	128.0
29	128.3	128.6	128.9	129.3	129.6	129.9	130.2	130.5	130.9	131.2
30	131.5	131.8	132.1	132.5	132.8	133.1	133.4	133.7	134.1	134.4

To be read: A mental age of 63 months (5 years, 3 months) has a cma value of 19.5; mental age of 120 months (10 years), cma value of 60.0; etc.

* Values from this point on are extrapolated on assumption that mental age increments beyond this point are equal.

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THE RELATION BETWEEN METABOLISM AND HEIGHT AND WEIGHT DURING ADOLESCENCE

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Previously, in reporting seasonal variation in physiological functions during adolescence (2), we commented briefly on the interpretation of our data in terms of Nylin's "growth rhythm" hypothesis. Nylin (3) had found higher BMR's during periods of accelerated growth in stature among Swedish children, and the increased rates of growth occurred on a seasonal basis. He suggested that the seasonal variations in both measures reflect an underlying "growth rhythm," in the sense that acceleration in one aspect of growth, physical, tends to be accompanied by acceleration in another aspect, metabolic activity. This concept of the relationship between physical growth and metabolic activity has also been discussed by Wetzel (5). Although our seasonal data did not lend themselves to such an interpretation, the possibility of correlation between different aspects of growth deserves explicit investigation.

It should be noted that the term "growth rhythm" as used here does not refer to the long term growth cycles occurring between birth and adolescence. Instead, it concerns the phase relationships of different aspects of growth during any developmental period, as in the familiar hypothesis that during early childhood there is a reciprocal relationship between the development of locomotor skills and language. This illustration also makes the point that the hypothesis of a *positive* correlation is not obligatory. One may simply ask whether rates of growth in physical measures such as height or weight are related in *any* systematic fashion, positively or reciprocally, to one or more of several indices of physiological functioning. But, if one does favor the notion of a *general* underlying growth rhythm, he expects different individuals to exhibit similar patterns of interrelations, and he expects those interrelations to be positive. Positive relationships are also suggested by the normative data, since both height and weight and also the total calories produced by the body increase more and more slowly after the puberal growth spurt. However, if one is neutral about a general growth rhythm hypothesis, he will consider the possibility of complementary patterns—a temporarily increased rate in one aspect of

development associated with a temporarily decreased rate in another aspect, and the question of whether different individuals show similar patterns of interrelations becomes entirely empirical.

Subjects and Procedure

The subjects are 52 boys and 52 girls of the physiological panel of the Adolescent Growth Study (1).[1] This group was chosen for a number of reasons. In the first place, longitudinal measures for both physiological and physical development were now available on the same subjects, and longitudinal measures are, of course, essential for any investigation of rates of growth. In addition, adolescence is a period that we already know to be characterized by systematic changes in rate of growth for some single functions (e.g., growth in stature) and since such systematic changes are a prerequisite of an investigation of the relationships between rates of growth, it seemed a likely age period to consider.

The four physiological indices which we have examined for their relationship to rate of growth in height and weight are these: BMR (expressed as calories / square meter / hour), total calories produced per hour, rate of change in BMR, and rate of change in total calories per hour. Strictly speaking, only the latter two are rates in the developmental or longitudinal sense. In using them, we ask whether the *rate* with which an individual's metabolism approaches a mature level is related to the *rates* with which his height and weight approach maturity. Both, rather than one or the other, are used since we have no particular reason for thinking one a more likely candidate than the other. For the first two measures—BMR and total calories per hour—the argument runs as follows: Presumably rate of growth reflects underlying physiological processes. If so, then rates of anatomical growth ought to show significant relationships with some index of the level of physiological functioning. Oxygen consumption and heat production are frequently used as this sort of index. Again, we have no particular preference for one or the other and have therefore tried both.

Measures were taken at approximately six month intervals[2] between the ages of 11.5 and 17.5 years. Three metabolic determinations were made

[1] Harold E. Jones directed the investigation. Nathan W. Shock was in charge of the physiological data collection. The anthropometric program was administered by Herbert W. Stolz.

[2] This rather large interval between measures increases the likelihood of obtaining the same sort of correlations as would be implied by a straightforward interpretation of the normative trends. With very short intervals between measures there is a much greater possibility of finding other sorts of relationships which long intervals might mask. With long intervals there is no doubt that rates of growth in height and weight will correlate positively; but very small intervals might show that a temporary spurt in growth in height is accompanied by a temporary lag in growth in weight and vice versa. With long intervals any such minute phenomenon is simply obliterated by the long range trend.

on each of two successive days[3] and the values used here are the average of all six determinations. Height and weight were taken in standardized procedures with the subjects nude during the semi-annual physical examinations.

Method of Analysis

To determine rate of change, the difference between each pair of adjacent measures for each subject was divided by the time interval between them. This was done for height, weight, BMR and total calories. In addition, we wanted the average BMR and average total calories for each time interval between measures. These were determined simply by averaging the measure at the beginning of each interval with that at the end. Following these transformations the rate of change for height (Δ height / time) and weight (Δ weight / time) were correlated (rank order) with each of the four physiological indices. Since these correlations were computed for each subject separately, the number of cases upon which each correlation is based is, of course, small. The median N is 9 for girls and 10 for boys.

Results

The distributions of the correlations for individuals and the median correlations are given in Tables 1 and 2.

For girls, the medians of the distributions of correlation coefficients are all positive except the two involving the rate of change in BMR. We are inclined to discount these exceptions, and to conclude that for girls the data indicate generally positive interrelations. We discount the exceptions for two reasons: in only one of them is the number of negative correlations significantly different from chance and then at only the 5 per cent level; secondly, in the group data (4) decline in BMR is almost linear. If the decline is truly linear, then of course the measures of rate of decline differ among themselves only as a result of chance and the correlations must approximate zero.

For boys the picture is not so clear. If we again discount the two correlational distributions involving rate of change in BMR, four of the remaining six distributions have the expected positive medians; three of these have a significant proportion of positive signs. We still must account for the significantly negative relation between average total calories and rate of growth in height and the zero correlation for average total calories and rate of growth in weight. Among boys the total number of calories produced per hour increases throughout adolescence, while the increments of height become smaller and smaller. The negative relationship between average total calories and Δ height / time probably reflects these facts. If this interpretation holds, then a similar negative median ought also to be

[3] Details of the procedure are given in (4).

TABLE 1

DISTRIBUTIONS OF CORRELATIONS — GIRLS

	Δ Height / Time ×				Δ Weight / Time ×			
	Δ BMR / Time	Δ Total Calories / Time	Average BMR	Average Total Calories	Δ BMR / Time	Δ Total Calories / Time	Average BMR	Average Total Calories
r	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
+.91–1.00	0	2	5	5	1	1	1	1
+.81– .90	1	2	13	3	1	2	2	2
+.71– .80	0	0	15	1	0	0	5	2
+.61– .70	1	0	7	7	0	4	6	1
+.51– .60	0	2	3	2	1	5	9	6
+.41– .50	1	4	1	1	2	2	7	3
+.31– .40	3	7	1	6	4	8	4	3
+.21– .30	2	6	0	3	2	7	4	5
+.11– .20	2	5	0	4	4	5	3	5
+.01– .10	8	7	2	2	7	4	5	8
.00	0	0	0	0	1	0	0	1
−.01– .10	4	4	1	2	6	2	3	3
−.11– .20	9	6	1	0	4	4	1	6
−.21– .30	2	2	0	0	3	3	0	1
−.31– .40	11	1	0	4	6	1	0	2
−.41– .50	1	3	1	2	5	1	1	1
−.51– .60	4	0	0	2	1	0	0	0
−.61– .70	2	1	0	3	1	0	0	1
−.71– .80	1	0	0	3	0	0	0	0
−.81– .90	0	0	0	2	2	2	0	0
−.91–1.00	0	0	2	0	1	1	1	1
Median	−.15	+.13	+.74	+.25	−.06	+.25	+.45	+.13
N	52	52	52	52	52	52	52	52
%+	35	67	90	35	42	73	88	69
%−	65	33	10	65	56	17	12	31
*p**	< .05	< .02	< .01	< .05	....	< .01	< .01	< .01

* Sign test.

TABLE 2

DISTRIBUTIONS OF CORRELATIONS — BOYS

	Δ Height / Time ×				Δ Weight / Time ×			
	Δ BMR / Time	Δ Total Calories / Time	Average BMR	Average Total Calories	Δ BMR / Time	Δ Total Calories / Time	Average BMR	Average Total Calories
r	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
+.91–1.00	0	1	4	0	0	1	2	0
+.81– .90	0	1	5	0	0	1	1	0
+.71– .80	0	3	2	1	1	6	4	1
+.61– .70	1	3	3	1	2	3	2	1
+.51– .60	2	3	4	3	4	4	6	3
+.41– .50	2	2	4	1	5	8	2	6
+.31– .40	3	5	6	1	4	7	6	5
+.21– .30	3	3	4	2	4	5	3	6
+.11– .20	3	7	4	2	6	4	2	3
+.01– .10	3	9	4	3	5	2	3	1
.00	2	0	1	0	1	0	1	1
−.01– .10	10	3	1	10	3	4	6	5
−.11– .20	8	5	3	2	5	2	3	6
−.21– .30	5	2	3	2	1	2	1	3
−.31– .40	3	3	0	4	3	1	3	3
−.41– .50	1	1	3	6	4	1	5	3
−.51– .60	2	1	1	4	1	0	0	1
−.61– .70	2	0	0	4	0	1	2	1
−.71– .80	1	0	0	5	1	0	0	1
−.81– .90	0	0	0	0	1	0	0	1
−.91–1.00	1	0	0	1	1	0	0	1
Median	−.07	+.12	+.35	−.20	+.10	+.35	+.20	.00
N	52	52	52	52	52	52	52	52
%+	33	71	76	27	60	79	60	50
%−	63	29	24	73	38	21	38	48
*p**	<.10	<.01	<.01	<.01	<.20	<.01	<.20	....

* Sign test.

found for the correlation between average total calories and rate of growth in weight, but the value is literally zero. This discrepancy may be due to the puberal growth spurt in weight which comes later than the spurt in height and which for boys comes at about the middle of the age span involved. That is, rate of weight gain first increases and then decreases while total calories increases throughout. Thus a generally positive relationship in early adolescence may be combined with a generally negative one later, yielding an overall index of zero. Among the girls, incidentally, the years of late adolescence are generally marked with a *loss* in weight and a *decrease* in total calories produced by the body, hence the positive coefficients.

We may summarize the findings as follows. In both sexes the correlations follow pretty directly from the normative data. For both boys and girls the rates of growth in height and weight are positively related to average BMR and to rate of change in total calories produced by the body. For both sexes the correlations with rate of change in BMR are small and insignificant. The major sex difference in these data involves the correlations between rates of growth and average total calories. For girls the two median coefficients are positive, while for boys one is negative and the other is zero. We have suggested that these differences can be understood in terms of the different timing of the growth spurts in height and weight in the two sexes.

Discussion

How are these findings to be interpreted? We could simply note that we find just those relationships which would be predicted from a knowledge of the group age trends of the indices of anatomical and physiological growth we have used. While this entirely statistical account avoids the pitfalls of overly speculative theorizing, it does not tell us enough about the hypothesized relationship between rates of increase in different aspects of growth. We would like to know whether there is a pattern of interrelations that is common to many individuals. Do individuals reflect the constellation of intercorrelations shown in the tables? If so, then we may speak more confidently of a general growth rhythm underlying the whole set of correlations. In short the question is this: "Do most individuals have the same pattern of signs shown by the medians of the separate distributions in Tables 1 and 2 or are there many different patterns?"

The procedure we followed in attempting to answer this question is as follows. Since distributions which do not differ significantly from chance offer little basis for prediction of individual cases, we omitted them from consideration and selected only those distributions which had a significant (1 per cent level) proportion of positive or negative signs. Thus, from columns 2, 3, 4 and 6 of Table 2, the pattern of signs for boys is: Δ height / time $\times$ Δ total calories / time—positive, Δ height / time $\times$ average BMR

—positive, Δ height / time × average total calories—negative, and Δ weight / time × Δ total calories / time—positive. Then, for each sex separately, we examined each individual's correlations to see whether his pattern of signs was identical with that shown by the table.

This procedure discloses that 25 girls and 21 boys have such patterns. That is, 40 per cent of the boys and 48 per cent of the girls show exactly the pattern of relationships that is revealed by the grouped data. This point suggests that the normative data are useful for predicting not only a single correlation within a given individual, but also that they are useful for predicting *several* correlations—a pattern of correlations—within a given individual. This last fact supports the concept of a general growth rhythm since the fact is not a statistical necessity. It could have been the case, for instance, that very few individuals showed the pattern revealed by the grouped data. This would occur if the individual cases responsible for the significant sign in one distribution of correlation coefficients tended to be different from the individual cases responsible for the significant sign in other distributions. In this event, there would have been no single pattern common to very many individuals.

The limits[4] for the proportion of individual cases having the same pattern as the group pattern can be determined from Tables 1 and 2. For girls, from columns 3, 6, 7, and 8 of Table 1, we find the upper limit to be 69 per cent and the lower limit to be 20 per cent. For boys, from columns 2, 3, 4, and 6 of Table 2, we find the limits to be 71 per cent and 0 per cent. For both boys and girls then, the proportion of cases having patterns identical with the group pattern is well above the lower limit.

But we must consider chance as well as the limits. Chance leads us to expect 40 per cent of the girls (.90 × .73 × .88 × .69 from columns 3, 6, 7, 8 of Table 1) and 31 per cent of the boys (.71 × .76 × .73 × .79 from columns 2, 3, 4, 6 of Table 2) to have patterns which are the same as the group pattern. The obtained proportions, .48 for the girls and .40 for the boys, exceed the chance values only very slightly. In other words, the patterns of relationships vary almost as much as the intercorrelations between the single variables permit. Evaluated this way, the similarity of pattern among different individuals is not great enough to support the concept of a general growth rhythm underlying both physical and physiological development. In fact, it is individual differences, rather than similarities, which characterize the relationships between rates of growth in

[4] The upper limit is set by the distribution which has the smallest proportion of appropriate signs. Thus, for girls, from column 8 of Table 1 the upper limit is 69 per cent. The lower limit is determined by elimination. In the case of girls we may begin with the 90 per cent in column 3 who have a positive sign and ask how many of the 90 per cent *could* be lost. That is, how many could have a sign other than the "correct" sign in at least one of the three remaining distributions. Twenty-seven per cent could be lost in column 6, 12 per cent in column 7, and 31 per cent in column 8. The remaining 20 per cent *must* have the same pattern as shown by the grouped data.

height and weight and the indices of both metabolic level and rate of change in metabolic level.

Summary

In an effort to find evidence relevant to the hypothesis that a general growth rhythm governs both physical and physiological development, we have examined, for members of the Adolescent Growth Study, the intra-individual correlations between rate of growth in each of two physical dimensions—height and weight—and each of four physiological variables. The physiological variables were rate of change in BMR, rate of change in total calories produced per hour, average BMR during each growth interval, and average total calories produced per hour during each growth interval. In general, the intra-individual correlations confirm the normative expectations, and a sizeable number of the distributions yield significant sign tests.

In addition we find that between 40 and 50 per cent of the cases show a *pattern* of interrelations which is identical with the pattern indicated by those correlational distributions which have a significant proportion of positive or negative signs. This similarity in the patterns of different individuals, while a useful empirical fact, is not sufficiently great to necessitate the concept of a general growth rhythm.

The major sex difference concerns the intercorrelations between the total amount of heat produced by the body and rates of growth in height and weight. This difference may be due to the earlier maturing of girls as compared with boys and the consequent difference in timing of the adolescent growth spurt.

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TRENDS IN THE PSYCHOLOGICAL APPRAISAL OF CHILDREN

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We are gathered today to celebrate the silver anniversary of the founding of the Psychological Clinic here at Rutgers University by the distinguished Dr. Henry E. Starr. This is the same clinic which today is flourishing and serving the people of the state of New Jersey under the able leadership of Dr. Anna Spiesman Starr. On an occasion such as this, it is appropriate that we take stock by reminiscing over the past 25 years to see whence we have come, and to take a long look at the present with a view to directing our sights in the future.

Under the general theme of *The Assessment of Men* I have been asked to direct my remarks to the trends in the psychological appraisal of children. There seem to me to have been a number of significant trends or shifts of emphasis which have been discernible during these 25 years of the existence of the clinic here at Rutgers University. Some of these trends are concerned with emphases on different major topics as foci of investigation in work with children. We might well ask ourselves what new tools of importance we have developed, and whether we have sharpened our old tools or learned to use them more skillfully. We might also look for trends in the amount of attention given to different age groups, as well as to variously identifiable clinical groups.

In general, it seems to me there has been a convergence of the developmental and the clinical points of view in child psychology. Large-scale studies, using cross-sectional and longitudinal methods, quite early blocked in norms on representative samples of subjects which now serve as frames of reference in the study of clinical deviates. Problems growing out of the

[1] Presented on Oct. 23, 1954, as part of a symposium on *The Assessment of Men* in honor of the twenty-fifth anniversary of the founding of the Psychological Clinic at Rutgers University, New Brunswick, N.J.

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crying needs to be met in service agencies dealing with children seem to have led to the emergence of numerous investigations concerned with deviant groups which are compared with norms already available from genetic studies. Examples may be cited in the work of Doll (13) with the feebleminded, Benda (7) on Mongolism, that of Bradley (8) on childhood schizophrenia, Strauss and Lehtinen (36) on the brain-injured, and Myklebust (27) on children with auditory disorders. Other special groups which have been the objects of intensive study are the bilingual and the epileptic as well as the speech defective and reading disability groups. Thus, the laboratory furnishes techniques for the clinic, and the clinic supplies subjects for the research worker in the laboratory.

Another development which has occurred is that many techniques which were devised for preschool or school-age children have been carried both up to higher age levels and downward to lower age levels. Individual intelligence tests for example, originally developed for school children, have been extended downward in the work of Kuhlmann (21), Gesell (15), Cattell (9), and Bayley (6) and upward to adulthood in the work of Wechsler (42), Babcock (4) and others. Some tools, originally employed on the adult level, have been extended downward for work with children, notably the Rorschach and the TAT; even the Wechsler has been brought down to the child level. Language development first intensively delineated at the preschool level has been extended downward in Irwin's (18, 19) investigations of infant speech and upward in the fields of semantics and psycholinguistics.

Earlier workers in the child guidance clinics of the twenties were concerned primarily with the child as a focus of study and treatment. While the child himself is not neglected or overlooked in more recent work, it appears that a relatively small percentage of the problems are due to organic defects, so that increasingly the clinician's attention is being directed away from the organism and toward the environment in which the child lives. This leads him to concern with the people closest to the child who shape that environment psychologically, so that, increasingly, parents are becoming the focus of attention, and are being treated either instead of, or most often, concurrently with, the child. Not only are mother-child relationships being stressed, but we are also seeing an increasing recognition of the importance of the role of the father as shown in the recent studies by Tasch (38) and by Stolz (35).

Even when the origin of the problem is a physical or mental defect in the child, the treatment now involves some form of individual or group therapy with the parents of the handicapped child in order to help them to accept the child's handicap objectively and without undue guilt feelings. The spontaneous groupings of parents whose children suffer from similar handicaps, such as the League to Help Emotionally Disturbed Children, The National Association for Aid to Retarded Children, and the United

Cerebral Palsy Association are interesting examples of how parents are finding strength and courage by banding together to provide for the needs of their handicapped children, and to seek professional help for their common problems.

Along with the increased interest in environmental factors is found increased interest in social class differences, racial differences and cultural factors, especially in the effects of various child caring practices as they are employed in relatively homogeneous groups. Whereas research workers have long used socio-economic status as a check on sampling, because many variables were known or suspected to be related to it, we now find efforts directed toward spelling out what are the dynamic factors in the way of life of various social groups which bring about the results obtained. This is only one illustration of the fact that child psychology seems to be moving away from mere description of how children grow and develop, as in the work of Gesell, toward explanatory phases attempting to get at the "whys" of their behavior.

Davis and Havighurst (12) blazed the trail and questioned many interpretations of test results on the grounds of cultural factors. Studies, like that of Milner (24), show that it is not merely the fact that children belong to one social class or another that makes the differences psychologically, but that membership in such a group increases the likelihood of being treated in certain ways, and of having certain kinds of life experiences which have important bearing on the rate and direction of development in many psychological traits. In other words, the quality of living differs from one social group to another. Life for children in one social group promotes healthy psychological growth, and in another it contains many influences which hamper that growth and prevent children from realizing their potential. This does not mean that children in upper social groups do not suffer the same hindrances to optimal growth. They can, and often do, experience the same conditions, but are merely less likely to do so.

With regard to child caring practices, Vincent (40) points out that the practical literature has gone through cycles from one extreme to the other. Currently it emphasizes such aspects as the psychological loss to the child who is bottle fed, in contrast to health and mortality figures which were formerly stressed, in urging breast feeding of infants. He also notes a marked rise in the number of articles recommending rigid feeding schedules and a policy of letting the baby cry it out which appeared between 1890 and 1920, and a complete reversal of this trend in favor of self-regulation and mothering techniques by 1948. He further indicates that the literature is now less dogmatic than formerly and that it is more likely to suggest alternative procedures. He states, ". . . it is painfully clear that the writers in the field of infant care and child rearing disciplines have been slow to construct a body of data that withstands empirical scrutiny. Instead, they have often reflected changing patterns of thought in middle

class society and reflected changing theories of education and personality formation" (p. 205). He brings out further that if the discipline of infant and child care is to become really scientific, the basic assumptions will need to be made more explicit in order to enable proper testing of hypotheses. The trends seem to have been recently in the direction of increasing recognition of the child as an individual in his own right, or increasing permissiveness, decreasing authoritarian practices and increasing use of democratic methods in dealing with children in homes and schools.

One important factor contributed by child psychologists which is often missed completely by psychologists who concentrate on work with college students, soldiers or employees is their emphasis on the matter of time perspective. Child psychologists are concerned with the developing organism in whom changes occur at different rates in various functions along a continuum. Valuable insights are often realized when events in the development of groups or of individuals are aligned in terms of time and studied for simultaneity and sequence. Changes in infant speech for example become more intelligible when related in time to such factors as dentition, use of solid food, assumption of the erect posture, etc. Individual clinical cases become much clearer when events in the life of the individual are studied in relation to the onset, worsening and lessening of symptoms. Regressive behavior and infantile symptoms often follow the birth of a younger sibling, or a severe fright. Stuttering sometimes has its onset or becomes aggravated following operations, or about the time adolescents begin to neglect the practice of their religion. Often non-readers have had emotionally traumatic experiences such as a change of home or the arrival of a new brother or sister at just about the time they were expected to learn to read. It seems that the more accurately we can date events in the past history of the individual and relate these events in time to the developmental processes which are in the ascendancy at the time of the traumatic experiences, the better are we able to account for presenting symptoms.

Twenty-five years ago much of the literature in child psychology was characterized by small-scale research investigations which attempted to study one factor at a time as a possible cause of another. Examples are the studies attempting to show that change of handedness was causally related to stuttering, or that aniseikonia was *the* cause of reading disability. Most such studies representing the search for a single cause led into blind alleys and inconclusive results. Accordingly we have witnessed a growing recognition of the complexity of the organism as a whole. The child presenting a given symptom is seen, not as a thief, or a runaway, a speech defective or a non-reader, but as a disturbed child who happens to manifest a certain symptom, or more often a group of symptoms, at a particular time. We have come, therefore, to think more in terms of patterns or syndromes of presenting symptoms which usually have not one, but many causes. The fact that causation is usually complex rather than simple leads

necessarily to the multidisciplinary approach to the problems of human behavior. This is well illustrated by the team approach of the child guidance clinic, and also by the major contributions coming more recently from multidisciplinary research teams operating under grants of money from foundations, rather than from isolated doctoral dissertations as in former years.

In the twenties, babies were stimulated in laboratories with flashlights, rattles, bells and telegraph snappers. In the thirties, the careful researches of Pratt, Nelson and Sun (29) and of Irwin (18), using the stabilimeter polygraph, showed the importance of the careful control of the entire stimulating situation as well as the condition of the organism at the time of stimulation. In the forties, important contributions were made concerning the development of babies in family situations as compared with those raised in institution settings. These steps seem to have led slowly but naturally to the emphasis of many current studies on the observation of the infant and the mother in all the complexities of their personal interaction in actual life situations, as in the work at the Menninger Clinic and more recently at Yale by Murphy (26) and Escalona (14). Paralleling this work at the infant level are the ecological studies of older children in their natural habitat by Barker (5) and his associates in Kansas.

In the twenties and thirties, clinics and researchers worked intensively with their newly fashioned tools, the intelligence and achievement tests. Helpful as these instruments were and still are, we have come in recent years to recognize their limitations, and to realize that affective and motivational factors are often more important determiners of adequate behavior in life situations than indices of intellectual potential. Clinicians are all too familiar with cases whose psychometric results present a picture of normality, or even superiority, yet whose adjustment is far from satisfactory. In such cases, psychometrics yield negative clues. They may tell us that the child's behavior cannot be accounted for on the basis of mental deficiency, and hence we are forced to study him further in order to find the key to the case.

In many other instances, mental measurement with standard intelligence tests gives only a minimal estimate of the child's ability rather than an index of capacity. The tests indicate merely that the child can do at least this well under present circumstances, which often include conditions of severe anxiety, fear or insecurity. After therapeutic relief from tension, such children often reveal much higher test scores. Thus, if we can discern yet another trend, it might be described as a decreasing emphasis on the importance of intelligence test results as such, combined with increasing emphasis on techniques of appraising personality and motivational factors.

Now that we have come to recognize the limitations of general tests of intelligence, and have learned from factor analyses of mental test data that there are many different abilities to be measured reliably, rather

than only one general ability, the next step will probably be, as Anastasi (2) suggests, the development of differential aptitude batteries as individual tests for children which will be based on empirical findings rather than on subjective guesses, so that profiles of several abilities and aptitudes will replace the former emphasis on single scores such as IQs, and the present dubious practice of analyzing patterns of unreliable subtest scores.

Unfortunately our techniques for studying the motivational and affective aspects of child behavior have lagged behind. They have proven extremely difficult to render objective and quantitative. In the past, most clinical reports were based primarily on objective numerical scores. While we still use these and find them very helpful, the clinician currently devotes considerable additional time to tracing themes in apperception tests, categorizing responses to sentence completion tests or to picture frustration studies, as well as to detailed analysis of the characteristics of children's drawings and to the study of their responses to Rorschach ink-blots and their behavior in play situations. Thus, it seems that we discern some trends away from exclusive emphasis on quantification toward extensive explorations in terms of more qualitative analyses. We are groping for objective and reliable ways of quantifying these important qualitative aspects of child behavior. Until we make major improvements in techniques for measuring such things as emotional immaturity, insecurity, parental rejection or permissiveness, we are unlikely to arrive at answers to many of the urgent problems of child psychology which will satisfy scientific research investigators. Unless we dare to dream, however, and set up tentative hypotheses to be tested, we will not find the answers, for we will not have the motivation or the felt need to forge the necessary tools of research.

Along with this search for ways of assessing some of the more subjective and subtler aspects of behavior, there are evidences of increasing willingness on the part of some psychologists to give due recognition to the importance of the moral and religious development of the child. Jersild's (20) emphasis on "the self" and the child's "private world" in the fourth edition of his text as well as the writings of Arnold (3), Ligon (23), Mowrer (25), and Walters (41) show increasingly that serious thinking is going on in such areas. These problems are not readily amenable to research, if indeed they ever will yield fully to objective investigation. But without them, our picture is necessarily incomplete. With the spiritual reawakening, however, which seems to characterize this atomic age in which we live, psychologists too, are relaxing their earlier defenses of agnosticism and are recognizing the central role of ethical values, and that the well-adjusted person lives the good life and enjoys a kind of inner peace, relatively free from guilt feelings and consequent symptoms of defense mechanisms.

During the 25-year span we are reviewing today, many of the children who participated in some of the earliest scientific and normative studies have reached adulthood and have themselves become parents. They consti-

tute a most important strand in the ever growing product of scientific knowledge which is being woven, slowly but surely, by a small group of developmental psychologists who have dedicated themselves to major longitudinal studies. I am thinking particularly of the work of Terman (39) who devised one of the most useful, if not the most useful single psychological instrument, in order to identify gifted children; then studied one thousand of them in detail, together with their parents; and who is now launching a study of the offspring of his original group of gifted children. I also think of the work of Bayley (6) at California, of the Harvard Growth Study, as well as of the work of Olson (28) at Michigan and that of Goodenough and Katherine Maurer Cobb (16) at Minnesota. These longitudinal studies provide invaluable checks and balances for our more quickly executed cross-sectional studies. We are witnessing longitudinal studies reaching from the cradle to maturity, and we are also seeing studies of three generations by the same workers like Radke (31), who studied not only the parents of child subjects but also their grandparents through the retrospective reports of the parents.

Another prominent focus of attention during the span of years we are considering today concerns the quality of the family relationships and the dynamics of parent-child interaction so well described by Symonds (37). It was Allen (1) of the Philadelphia Child Guidance Clinic who called attention to the fact that most deviant behavior of children requiring clinical services represents some deviation from the normal in the mother-child relationship. The vast majority of children requiring therapy seem to be suffering from being pushed out of the nest too soon by rejecting parents, or to be in need of assistance in the emotional separation from the mother in order that the child may be emancipated from an overprotecting mother and achieve emotional independence. Levy (22) has made outstanding contributions in this area.

Other evidences of the swing away from the purely quantitative measurement of human behavior may be seen in the rather general recognition that the schizophrenic child (a diagnosis which is made much more frequently now than formerly) is somehow qualitatively different from the normal child in his behavior. Witmer (43), too, has made interesting distinctions between the mentally healthy child and the neurotic child, and Strauss and Lehtinen (36) have given valuable descriptions of the behavior of the brain-injured child. Benda (7) has also shown that the developmental anomalies in the severe psychopathological conditions are qualitatively different and proposed that "the field of psychopathology of childhood be considered as the realm of developmental disorders of mentation, and that each group be considered according to its own merits" (p. 1117). At a recent symposium Cobb (10) challenged the idea of explaining much neurotic behavior in terms of emotional immaturity, for she claims that the behavior of the neurotic adult is qualitatively quite different from the

normal behavior of a younger individual, and she suggested that perhaps the developmental concept of immaturity to account for such deviant behavior has outlived its usefulness.

We have come a long way from the early biographical studies of Darwin (11), Preyer (30), Scupin (32), the Sterns (34), and Shinn (33) and from the questionnaire studies of Hall (17). We have lived through an era of objectivity and measurement which bore fruit in the form of limited tools and some fairly adequate norms. Perhaps the present phase is analogous to a period of retooling in industry as we examine new hypotheses and work with new theoretical constructs in entering upon a second descriptive period, awaiting the perfection of new instruments, which we hope will enable us to quantify our observations of new and more complex variables in a future phase of more adequate explanation leading to enlightened understanding of child behavior.

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